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# CONSERVATION AND EYE MOVEMENTS IN A READING RELATED TASK

By

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled Conservation and Eye Movements in a Reading Related Task, submitted by Eileen Sweeting Jackson in partial fulfillment of the requirements for the degree of Master of Education.

ABSTRACT

Controversy regarding the role of perceptual-conceptual development in the reading process indicated a need to empirically evaluate attentional behavior in good and poor readers. A rationale for an investigation of perceptual-conceptual abilities was derived from the theoretical positions of Piaget, Wohlwill and Bruner as well as the empirical suggestions of Mackworth. It was suggested that perceptual-conceptual differences could be identified between good and poor reading groups in terms of ability to decenter attention and effectively search visual arrays. Related research indicated an examination of conservation status, as measured by the Goldschmid and Bentler conservation tests, as well as visual search strategies, as measured by corneally reflected eye movement patterns, would provide both theoretical and pragmatic information about the way children learn to read.

Fifteen good and fifteen poor readers, 7 to 8 years of age, were tested on a battery of Piagetian conservation tasks which included; two-dimensional space, number, substance, continuous quantity, discontinuous quantity, weight, area and length. In addition, eye movement patterns of ten good and ten poor readers, who scanned pictorial and verbal stimuli to solve matching problems, were analized. The reduction in sample size on the eye movement task was due to problems of a technical nature.

Results indicated that perceptual-conceptual differences were noticeable between the reading groups. These differences were

identified on the basis of several variables (overall conservation behavior; conservation judgement; logical justification of conservation; location of initial fixation; latency to response; mean number of fixations and mean length of fixation). In addition, a tendency for poor readers to demonstate fewer between picture and word comparisons was noticed.

It was concluded that a relationship existed between conservation status, visual search effectiveness and reading ability. The data supported theoretical positions which emphasize the importance of perceptual-conceptual development to attentional behavior necessary in effecient reading. It was also indicated that the centrative attentional characteristics of poor readers in comparison to the more extensive perceptual activities of good readers was consistent with several theoretical and empirical perspectives. For example, support was rendered to positions taken by Piaget, Wohlwill and Mackworth regarding the dominance of perceptual cues in centrative perception, which lead to faulty conceptualization. Several implications for further research were noted.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

# INTRODUCTION

Regardless of the quantity of research done in the area of reading, controversy continues with respect to the nature of the reading process, especially in terms of the way in which young children learn to read. Since reading is a complex behavior composed of processes which are largely inferred, it has been suggested that the wide array of strategies employed to measure these processes have contributed to the controversy (Pick, 1970). For example, the similarity between processes involved in crawling, or perhaps dot matching tasks, and those involved in reading tasks is not readily apparent.

The relationship between perceptual and cognitive processes and reading has been considered the sine qua non of reading research. However, there is a paucity of documentation in this area. Historically, due to the orientation towards educational practices, reading theorists have often ascribed reading difficulties to the misperception of letters and words or motoric unorganization rather than to faulty abstraction and conceptualizational abilities. Pick (1970), however, maintains that the application of perceptual-motor studies to the reading situation does not corroborate the hypothesized relationships, for example, training on Frostig Programs for the Development of Visual Perception (Frostig, 1964) improves performance on Frostig tests, but not on reading tasks. Furthermore, studies which relate perceptual-motor problems to reading abilities are generally correlative rather than casual in nature (Hallahan and Cruickshank, 1973). Most importantly, few

studies have investigated the perceptual-cognitive processes involved in reading even though there is evidence to suggest that reading skills relate more to cognitive ability than to I.Q. (Braun, 1963). In line with this position, MacGinitie (1973) noted the need for more basic tools which predict reading problems and identify specific stages in the acquisition of reading.

Due to the current influence of Piagetian thought on education and child psychology, it seems appropriate to examine the reading process in terms of stepwise, sequential, perceptual-cognitive patterns. Moreover, this suggests that measures of perceptual-cognitive development should be considered both in the differential diagnosis of reading disabilities and in the format and reading materials. The implication of such an examination would be the construction of reading programs tailored to the needs of individual learners.

Subsequently, to gain insights into the nature of the reading process, Piaget's (1950) developmental theory will be examined in terms of how perceptual and cognitive processing relate to the development of attentional behavior necessary for effective reading. Bruner's (1966) theory of cognitive growth, which parallels Piagetian thought, is also relevant to this study as research in reading based on Bruner's theory (Elliot, 1970), substantiates results of reading research based on Piagetian postulates. In addition, Wohlwill's (1968) critique of Piagetian theory, and Gibson's (1967) alternative perception-conception explanation will serve to further stress the importance of perceptual-cognitive development in reading. Finally, Mackworth (1972), who has related

specific perceptual-cognitive skills to the reading process, will be considered since areas of research that he proposes (picture-word matching tasks) follow logically from the previously mentioned theories as important empirical pursuits.

The above theoretical positions suggest that the development of efficient attentional behavior is related to individual reading development. If this supposition is true, poor readers may indicate specific processing difficulties because they are drawn to, or centrate on, perceptually "appealing" aspects of the stimulus array at the expense of more informationally relevant dimensions. Several researchers have reported a relationship between level of perceptual activity and conservation attainment (Bruner, 1966; O'Bryan & Boersma, 1971; Piaget, 1950; Wohlwill, 1968). Briefly, it is suggested that with maturation subjects rely less on highly visible but irrelevant dimensions of the stimulus field, and through developing perceptual activity, increasingly decenter their attention and thereby attain conservation. Children who have not attained conservation may demonstrate inadequate perceptual-cognitive skills for efficient reading.

Several eye movement studies have dealt with problems which are particularly important to an investigation of attentional behavior during reading situations. For example, Yarbus (1967) states that, "eye movements reflect the human thought processes" (p.190). Neisser (1963) and Mackworth (1967) suggest that visual scanning records can be used to obtain direct and reliable measures on information processing. Furthermore, Mackworth and Bruner (1970),

Nodine and Steverle (1973), Schmidt (1966), Taylor (1965), and Vurpillot (1968) concur that there are developmental improvements in eye movement efficiency such that with maturation, perceptual ability becomes subordinate to more discriminative, cognitively directed ocular movements.

It is also important to note that Tinker (1958) maintains that it is erroneous to believe that training eye movements will increase efficiency in reading. Boersma and Wilton (1974), however, found that attentional behavior in a group of nonconservers could be modified such that their perceptual activity, as recorded by eye movement patterns, did not differentiate trained from natural conservers.

The purpose of this study, is to utilize an experimental task (a picture to word match situation) which will examine differences between good and poor readers in terms of decentrative attention behavior.

In line with this, it seems important to compare good and poor readers on Piagetian conservation tasks to assess whether conservation status is related to level of reading ability.

In addition, oculographic methods provide a particularly useful way of unobtrusively and reliably recording the nature of individual visual responses to reading tasks. Evidence of differentiations between good and poor readers paralleling perceptual-attentional differences, could contribute to an understanding of the nature of the reading process and augment the development of diagnostic and remedial procedures.

In summary, this chapter noted that whereas the reading literature discusses perceptual and cognitive processes as important to reading, there is little empirical support for this supposition. It was suggested that a study of conservation status and eye movement patterns during a picture-word matching task might help clarify the role of perceptual-cognitive processing in reading.

Chapter two reviews the literature relevant to the problem of the study, and states the general objectives and hypotheses. Chapter three describes the methodology and design. The fourth chapter discusses the results of the investigation. Finally, chapter five summarizes the study, states conclusions and makes recommendations for future research.

# CHAPTER 2

## Review of Related Research

### Perceptual-Conceptual Developmental Theories

The relationship between perception and conception has traditionally polarized philosophical and psychological theorists who have addressed themselves to the question of "how we come to know". Several researchers in the area of learning disabilities, especially those involved in reading problems, have suggested a process whereby problems in perceptual processing evolve into faulty conceptual processing (Bruner, 1966; Kepart, 1968; Werner and Strauss, 1939; and Wohlwill, 1968).

### Piaget's Position

Perhaps the most currently influential developmental theorist who has concerned himself with the perception-conception issue is Jean Piaget. Briefly, he has suggested that the ontogeny of thought pertains to reliable features of objects in general, which he refers to as "cognitive invariants" in that one or more of these invariants are acquired during each of four hypothesized stages of intellectual development, that is, sensory-motor, preoperational, concrete operational, and formal operational (Brainard, 1971). He essentially has posited an adaptive process view of intelligence whereby individuals, either through assimilation (the incorporation of information through previously acquired strategies) or accomodation (the development of alternate strategies), reconcile environmental and behavioral influences towards a balance or state of

equilibrium. Wilton and Boersma (1974) explained that:

> Because adaptation to environmental demands and organization of intellectual acts are functional characteristics which endure throughout the individual's lifetime, they are refered to as functional invariants. The raw material of intellectual adaptation consists of actions which are performed by the child. Initially these are slow and overt, but gradually they become internalized and increasingly abstract. A basic underlying assumption in Piaget's theory is that the acquisition of new responses reflects changes in the individual's mode of functioning, i.e., in his structures (p. 4).

Piaget (1969) places great emphasis on the importance of perceptual activity in cognitive development in that he discusses the development of logical structures in children in terms of figurative and operative aspects. Figurative aspects deal with perception, mental imagery and imitation, whereas operative aspects deal with inferential transformations. Perception is viewed here as a probablistic process dependent on immediate contact with the object, whereby the individual is engaged in a series of visual encounters (fixations or centrations) within the visual field. With the first encounter a specific element of the field is sampled, then each remaining element is examined successively. The final product of this process, knowledge of a stimulus, is said to be dependent on the constructive process of assimilating and coordinating multiple encounters over spatial and temporal dimensions.

Although Piaget maintains perception and cognition are two parallel processess, which display structural similarities, he subsequently states that they are sharply differentiated (Wohlwill, 1968). Piaget postualates perceptual "preinferences" which are partially isomorphic to inferential mechanisms, however;

> The differences between these perceptual preinferences and conceptual inferences can be found...in the certainty of outcome and in the subject's lack of awareness of steps in the preinferential chain (Wohlwill, 1968, p.477).

Specifically, Piaget maintains that developmental stages exist in the realm of intellectual, but not perceptual development in that qualitative differences occur in cognition, whereas quantitative differences occur in perception. Development is considered to be a function of the integration of perceptual and inferential processes. The continuity of transition from a totally perceptually bound world to the development of inferential reasoning is attributed to a gradual subordination of perceptual structures to intellectual operations (Piaget, 1971).

The gradualness of the transformation is illustrated in a study by Halpern (1963). She investigated the relationship between thinking dominated by perception and that guided by logic in a sample of 20 children, age 5 to 7. The supremacy of misleading perception was assessed in an experiment where perceptual and logical cues competed in problems on inference of measurement. Her results indicated that the residue of previous modes of thinking (perceptually bound) are still used in certain situations, after logical thinking is manifest. In other words, perception can be misleading even in the presence of logical thinking. The results further clarify the relationship between perception and logic at the onset of operational thinking.

As the child moves from perception to conception, less stimulus information is required. Therefore, as the child becomes more capable cognitively, he simultaneously becomes better equipped to

ignore irrelevant information. The development of attentional activities and conceptual abilities, then, are seen as concomitant (Hallahan and Cruickshank, 1973).

More specifically, Piaget (1950) maintains that during infancy the child is functioning at the sensori-motor level of intelligence. Between 2 and 5 years, sensory-motor schemas gradually become co-ordinated and internalized into cognitive structures. A young child's visual perception is initially centered such that the number and duration of encounters within the visual field are determined by field effects (primary illusions). At this early age, fixation of attention evokes an actual distortion of a visual array such that the point of focus tends to look larger, clearer, and brighter. Here perceptual development is at a static, centered stage where the child focuses visual attention on dominant details. Furthermore:

> The visual field may not be immediately perceived as a whole because of its size, complexity, context, failure to arouse the number of visual encounters necessary for its perception or its length of exposure. Then the effects of centered perception are responsible for perceptual errors (Blanton, 1970, p.14).

The result of centrative perceptual behavior is restrictive reasoning which characterizes children in this "preoperational" stage of development. Later (5 to 7 years), early cognitive structures become progressively organized into integrated systems of actions or operations. Qualitative "cognitive invariants" (those properties of objects that are of an "all or none", existance-nonexistance variety) are said to be within the province of these

first two stages of cognitive development (Brainard, 1971).

Field effects become less apparent due to maturation, and in particular with increased ability to coordinate perceptual activity, that is, the development of decentrative perception. Blanton (1970) suggests that perceptual decentration marks the development of more advanced perceptual structures enabling the child to perform active perceptual analysis. Specifically, he notes:

> Perceptual decentration heralds perceptual schema (activities for coordinating synthetic and analytic relationships over spatial and temporal dimensions dissociating the whole into its component parts and regrouping the parts according to a system of logic-like rules) which counteract the effects of perceptual centration (p.20).

For Piaget, the realization of reversability of actions or operations develops along with initial logic-like rules, as well as the gradual acquisition of notions of invariance of quantity or conservation. Conservation attainment is a key concept in perceptual-conceptual development and is described as involving thinking in terms of relationships between invariant properties and perceptual characteristics of objects. The acquisition of the notion of quantitative invariance, conservation, is seen to relate to the growth of operations which allow the progression from a rigid to a more logical stage of representing reality during the later stages of development, that is, concrete operational and formal operational.

Piaget (1962) views nonconservation of quantity as clear evidence of preoperational thinking and has used this premise to design developmental tests of conservation ability. Generally these tests require the individual to ignore irrelevant changes in stimuli, such

as differences in configurations of equal numbers of objects, and select one invariant element upon which to base judgements in the face of perceptual transformations.

It appears that there is a developmental progression in conservation attainment. In one sense certainty of judgement of invariance develops from reasoning based on changes of a single dimension, to a vaciliation between complementary dimensions and finally, to an understanding of compensation and reversibility of two or more dimensions. In another sense there is a development towards the complexity of invariance judgement. Brainard (1971) notes a distinction between first order qualitative invariants such as number, length, height, substance, weight, and areas (which are considered to be within the realm of concrete operations in that they only require reversibility of objects) and second order conservations such as volume, density, momentum, and rectilinear motion (which indicate formal operations and the ability to view reversibility of relationships amongst objects). Wilton and Boersma (1974) concluded that an ordinal scale of intellectual development for normal children appears to exist:

> number and discontinuous quantity attained at approximately ages 6 - 7; length, continuous quantity (substance or liquid) and area at ages 7 - 8; weight at ages 9 - 10; and volume at ages 11 - 12 (p.15).

The basic principles of the above progression appear to be that nonconservation or centrative behavior is reflected when a subject tends to fix attention on salient aspects of the stimulus field. Increased perceptual activity results in the shifting from

one centration to another, or decentration, which allows for the comparison and correction of centrated impressions. Côté (1967) seems to utilize the above principles to interface perceptual and conceptual development in that he states, for Piaget:

> Perceptual centrations and intellectual decentrations interact to free the child from egocentricity. However, it is clear that the superior modes of decentration aren't simple extensions of particular decentrations, such as might be seen in perception of a figure. On the contrary, it is perceptual activity which engenders perceptual decentrations, which give rise to superior modes of decentration. Once formed, the superior modes of decentration direct perceptual decentrations (p.177).

To summarize, changes in mental processes are generally viewed as being due to decreasing dependence on information in the immediate stimulus field. Wohlwill (1968), however, maintains that Piaget over-emphasizes differences between perception and conception, whereas the concept of parallel processes is highly important. He suggests that Piaget's postulates on the development of concepts are more profitably interpretable in terms of the increasing stability of concepts in the face of irrelevant changes.

<u>Bruner's Theory of Cognitive Growth</u>

Like Piaget, and Wohwill, Bruner (1966) maintains that as cognitive development proceeds, perception is less and less dependent on immediate stimulation. He further states that cognitive development subseqquently becomes more dependent on categorizations. Bruner's cognitive growth theory outlines a successive progression from an enactive, or action mode, to an iconic, or imaginal-perceptual mode, which in turn matures into a symbolic or reasoning mode of representing reality.

Bruner's iconic mode is particularly interesting as it is similar to the preoperational stage postulated by Piaget. Specifically, he maintains that perceptual illusions may overwhelm symbolic reasoning and elicit a nonconservation response. As the child matures, conservation attainment develops as a result of:

> The symbolic mode strengthening through the child's increasing awareness of the shortcomings of the perceptual delusions, arising from the iconic mode's attempts to resolve the conflict and eventually an understanding of the concept results (O'Bryan and Boersma, 1972, p.16).

Development here is attributed to the realization of a non-correspondence between modes of representation, which result in cognitive conflict, whereby the child can logically compensate for a conflicting series of events in which one mode of representation appears to be contradicted by another.

With respect to the preceeding postulates, Bruner substantiates Piaget's views on the importance of the development of perceptual-attentional behaviors in the development of logical reasoning. He is especially supportive in terms of the importance of effective processing of visual information, which is, of course, required in the reading process.

Piaget and Bruner differ, however, on several theoretical issues, one of which is the "problem solving model" which Bruner uses to describe the sequence of operations (hypothesis, trial and check, and matching to a category) attributable to perception. Perception, for Bruner, always involves an act of categorization. Piaget and Morf (1958) and Wohwill (1968) argue that Bruner's model presupposes an adult perceiver, in that a young child's

categorizational abilities are still forming.

Gibson's Distinctive Feature Model

Gibson (1969) takes exception to theorists such as Piaget, Bruner, and Wohwill in that she submits that there is an ever-growing reliance on perceptual information:

> Perception is not a process of matching to a representation in the head, but one of extracting the invariants in stimulus information... We do not perceive less because we conceive more...it would be maladaptive for getting information... (p.449).

She maintains that the perception of complex information, such as that involved in reading, requires a differentiation of distinctive features which are discovered by the perceiver. Through a "distinctive feature pattern" model for phonemes and graphemes, Gibson (1969) has provided a useful developmental analysis of the order of complexity in learning letter characteristics.

Specifically, for Gibson, reading involves learning to perceive symbols through three stages, which she suggests may parallel Piagetian stages in that children progressively learn features or dimensions of differences, critical to differentiating letters. First, symbols, that is, speech sounds and letters, are perceptually differentiated. Second, invariants of matching from the symbol set, to the set symbolized must be learned. Finally, an understanding that a set of symbols has rules for "how they may be put together in a sequence" or the "structure" of language is internalized.

To summarize, the previous theorists, Piaget, Bruner, and Wohlwill suggest that conceptual maturation results in a reduction

of dependency on immediate perceptual information, whereas Gibson purports that a more selective and extensive processing of perceptual cues results. Regardless of theoretical disagreements, consensus seems to be that cognitive development enables more subtle, relevant cues to be detected, which is conducive to progressively more complex information processing.

The theoretical positions presented corroborate the posited relationship of perception held by many learning disability theorists. Specifically, the formulations of Piaget, Bruner, Wohlwill, and Gibson together concur that erroneous perceptual processing will impede concept attainment (Hallahan and Cruickshank, 1973).

In conclusion, credence is lent to the possibility that children who rely on faulty perceptual-conceptual processing may have difficulty in learning to read.

## Mackworth's Suggestions for Research in Reading

In line with the above theorists, Mackworth is also concerned with the developmental aspects of attentional, perceptual and cognitive processing. He maintains that visual search develops from a state where attention is controlled by the nature of the stimulus features to a state of selective attention which is monitored by past experiences (1972). In addition, he applies his perspective empirically to investigations of the cognitive nature of the reading process. He maintains that the investigation of fixation patterns, to ascertain whether or not centrative behavior is related to pictorial-verbal processing in good and poor readers,

is particularly important.

With respect to the role of attention and reading, Mackworth (1972) reports that school children with severe language disabilities take longer than normal two year old children to habituate fixation of attention to novel stimuli. He also views pictorial processing as highly important since children who have difficulty in reading often demonstrate faulty pictorial processing. Kulman (1960) substantiates Mackworth's findings in that he maintains that development and concept attainment are more difficult for the child who still searches for vivid perceptual cues. Thus it appears that children must first be able to effectively process pictorial information before they can process verbal stimuli.

Specifically, Mackworth and Bruner (1970) found that the speed and efficiency of pictorial processing approached the maximum level of development in a sample of 20 children 6 years of age. However, verbal information processing time for the children was more than twice that required by a sample of 20 young adults. Most importantly, Mackworth suggests that an eye movement study of where children looked when presented with a picture-word matching task would indicate the nature of errors that were made, i.e., inadequate search strategies and failure to attend to important visual aspects.

In summary, the preceding theorists postulate perceptual and cognitive processing stages which appear to be directly related to developmental aspects of visual activity necessary for reading and suggest a novel empirical technique. The following research further implicates reading as important for the development of abstract

reasoning and suggests that poor readers may be at a stage where centrative perceptual behavior inhibits systematic information intake.

## Empirical Support for Developmental Aspects of Reading

### The Role of Piagetian Decentration in Reading

Specific investigations into the role of perceptual decentration in reading have been undertaken by Elkind and his associates (Elkind, 1964, 1966; Elkind & Deblinger, 1969; Elkind, Kroeger & Go, 1964; Elkind, Larson, Van Doornick, 1965; Elkind & Scott, 1962; and Elkind & Weiss, 1967). Elkind defines decentration as:

> Decentration is in fact the spontaneous shift in focus from one perceptual organization to another which is made possible through the development of perceptual regulations (1969, p.19)

Briefly, Elkind suggests that the theme that dominates reading research based on Piaget's model of cognitive development is that all perceptual processes embody a "kind of logic". He discusses this with reference to perceptual reorganization (the ability to mentally rearrange a stimulus pattern or array without acting physically upon it), perceptual schematization (the ability to organize parts and wholes where both retain their unique identities and their interdependence), and perceptual exploration (the ability to systematically scan an array, organizing the stimuli into serial order). Specifically, Elkind (1969) states:

> The ability to construct spatial seriation, for example, is clearly essential for comprehending the grammatical significance of word order. Reorganization likewise, would seem to be important to the analysis and comprehension of new words. In the same way, schematization of parts and wholes would appear to play an important role in dealing with prefixes and suffixes and with the tense and pluralization transformations of words...

> Finally, effective rapid reading would seem to require the ability to quickly explore and correctly anticipate (infer) words and sentences (p.202).

He concludes that perceptual decentrative activities seem to be important in all stages of learning to read skillfully.

The above conclusion is substantiated by Elkind's research. Using various techniques, his studies revealed, for example, that perceptual decentration was a factor common to both perceptual tasks and reading, that poor readers were inferior to good readers on perceptual decentration tasks, and profited less from training in perceptual decentration, and also that training in activities designed to improve perceptual decentration resulted in improvement on certain reading tasks.

In line with the above, it is interesting to consider possible implications for initial and remedial programs in reading. Approaches, for example, which emphasize exclusively the development of whole word recognition or individual letter recognition may require reconsideration in light of Elkind's suggestion that learning to read effectively involves shifting attention from individual letters to whole words and the coordination of this part-whole relationship.

Elkind's explanation of the involvement of decentrative behavior in reading, however, is not substantiated by the literature. For example, Blanton (1970) utilized a battery of tests, which included Elkind's Ambiguous Pictures Test (1964) to investigate the relationship between reading skill acquisition and the ability to perform operations requiring perceptual decentration. The sample studied consisted of 127 first grade boys and girls whose ages ranged from 5.9 to 7.0 years.

His results indicated a low relationship between perceptual decentration and reading readiness.

There are three factors which may contribute to the apparent discrepancy. First, according to Piaget, many children of the age range studied are at the preoperational stage of development and may not display what Piaget considers to be decentrative activity. Second, Blanton interpreted Elkind to say that the structures underlying perceptual decentration and perceptual operations necessary for effective reading are one and the same, or, that reading requires perceptual decentration. Perhaps there is an error of overestimation, that is, that perceptual decentration is necessary to all perceptual operations involved in effective reading, when perceptual decentration may only be important to certain aspects of learning to read. Finally, Pick (1970) suggests that Elkind's instruments might not effectively test decentrative ability.

As mentioned previously, one indication of decentrative ability, according to Piaget and Bruner, is the demonstration of conservation attainment. Developmentally, it seems significant that children generally begin to demonstrate evidence of efficient reading skills between the ages of 7 - 8. This is approximately the age that they are involved in early stages of conservation attainment during the transition from preoperational (perceptually dominated) to concrete operational (inferential) thinking. The ability to ignore irrelevant stimulus changes appears then to be of considerable importance to a child in learning even basic reading skills. For example, Rawson, (1969) notes that:

> Operation of conserving may be utilized in understanding that the referent of a letter, for example, of the 'm's in remember, of 'm' in mark and in Mark is conserved with change in position in the word and with change in the form of the letter (p.71).

Arnolt (1974) further maintains that although a preoperational child may know the phoneme equivalent of d, o, g, he does not know the graphemic-phonemic relationship of dog. She suggests that at this stage the child is not able to perform analysis on transformed words after they change their appearance and would have difficulty "sounding out" the phonemic equivalent of "a" on the following words: mat, mate, mark, and meat, since "he cannot memorize rules and then decode which words apply and which don't apply". Specifically, she notes:

> In presenting a child with both upper case and lower case letters, different type faces, manuscript and cursive writing and variations in assigning phonemes to particular letters, the non-conserving, transductive, preoperational child may experience failure in beginning to read. Analyzing this evidence indicates that it takes "concrete stage" thinking to be able to deal with parts and wholes of words and to think about all of the possibilities one letter of the alphabet might denote. Thus, in order to deal with the transformed letters and hold rules of relationships in mind while synthesizing meaning, a child must be a conserver, a concrete thinker (p.11).

A study by Johnson (1972) is supportive of the above contentions. His sample consisted of 42 dyslexic children, 21 of which were conservers and 21 were post conservers, and 60 normal readers, 30 of which were transitional conservers and 30 of which were conservers. When matched on chronological age, sex, IQ, socio-economic status, and reports of emotional stability, the results indicated that dyslexic children appear to have experienced a significant developmental arrest in their capacity to explain and judge conservation

phonemena.

Hurta (1972) also investigated the relationship between the ability to conserve and level of reading acquisition. Her sample consisted of 25 reading disabled (remedial class) children and 25 normal reading children, whose ages range from 7.0 to 8.5 years. A statistically significant difference in level of functioning on conservation was noted in that disabled readers functioned significantly lower on conservation of length. There was also a tendency for poor readers to have more difficulty with conservation of weight and substance than normal readers. However, as the disabled readers were apparently subjected to different arithmetic, science and language curriculums the comparability of their performance on conservation subtests may be somewhat questionable.

### The Cognitive Growth Theory and Reading

A recent reading study based on Bruner's cognitive growth theory is relevant as it substantiates Elkind's supposition regarding the importance of the development of perceptual regulations with respect to reading. Elliot (1970) compared 40 subjects classified as having primary reading retardation, 40 subjects classified as having secondary reading retardation, and 40 controls, on estimates of visual-motor perception, perceptual-language integration, and on verbal, language, and conceptual variables. The three groups were matched on chronological age, performance intelligence quotient and performance mental age on the Wechsler Intelligence Scale for Children, as well as on sex. His results suggested a developmental lag in poor readers which he attributed to a failure to progress to

to the stage of "symbolic" thinking.

Elliot concludes that progress in symbolic representation for reading seems to rest upon the ability to integrate iconic (perceptual) and symbolic modes. Initially this requires that imagery play a dominant role while language appears as the relevant development in later childhood. Therefore, the child's vocabulary grows from small "picturable" categories to more subtle "unpicturable" ones. He further maintains that as language increasingly becomes "decentered" from its concrete perceptual base, abstract conceptualization becomes more possible.

Rawson (1965) extends the previously presented conclusion to suggest that in fact reading is intrinsically important to the development of abstract reasoning:

> Reasoning from printed symbols may be particularly effective in the early consolidation of the acquisition of logical thinking. Reading if this were the case, could be one of the contributing factors in the realization of potential intelligence (p.23).

To summarize then, it appears that the ability to decenter or to shift attention selectively, may be an important developmental aspect of perceptual-conceptual processing, especially with respect to effective reading. Pick, Christy, and Frankel, (1972) maintain that the above conclusion seems congruent with findings cited in various fields of research which postulate greater selectivity of attention as a trend of perceptual development, that is, "selective listening, incidental learning, and stimulus dimension preference".

## The Role of the Development of Selective Attention in Reading

General findings with respect to the developmental aspects of selective attention indicate that, in older children, the type of task relevant information, the increase in intentional learning, and more stable dimension preference may reflect that they attend more selectively to their environment. Specifically, with respect to reading, it is interesting to note that, like Gibson, a recent study by Nodine and Steverle (1973) discussed the ability to process distinctive features of letters as being developmental. For example, the differentiation between b and d is noted as being more difficult than that between m and p. In order to determine how differentiation of letters is learned, Nodine and Steverle tested 36 boys and girls, 12 children from kindergarten, 12 from grade one and 12 from grade three, on pairs of letters which differed on the basis of confusability. The authors concluded that the perceptual efficiency of older children is attributable to more effective cognitive-attentional strategies and an expansion of the child's visual field.

## Use of Eye Movement Techniques in Reading Research

Further support for the increase in decentrative activity, as a function of normal cognitive development, has come from eye movement studies of children (Mackworth, 1971; Piaget, Ving Bang, & Mantalon, 1958) and of children and adults (Mackworth & Bruner, 1970). One particularly relevant investigation by O'Bryan and Boersma (1971) reports that nonconservers fixate attention, as measured by corneally reflected eye movements, on elements that

appear larger (the transformed element) while transitional conservers display less of this distinct centrative behavior. Conservers, on the other hand, showed decentrative behavior as measured by a greater number of comparative shifts between the stimulus elements. In short, their results support previous theoretical contentions that centrating on particular graphic aspects in a visual array appears to result in a dysfunction in processing and coding information. Subsequently, relevant aspects of a stimulus are not effectively integrated.

Several researchers have noted the value of using eye movement analysis in studying both information processing behavior and differences in cognitive development (Mackworth & Bruner, 1970; Nodine & Lang, 1971; O'Bryan & Boersma, 1971; Vurpillot, 1968; Wilton & Boersma, 1974 and Zaporozhets & Zinchenko, 1966). Moreover, this type of analysis seems to provide a promising means of directly addressing problems regarding the nature of the reading process, in that data can be obtained on interesting variables such as points of fixation, patterns of search, shifts of attention within and between stimulus arrays, and duration of centrative behavior.

In support of using eye movement analysis, Neisser (1963) maintains that the time required to execute cognitive operations in visual scanning reflects functioning of information processing. More specifically, Gould and Peeples (1950) found that the duration of eye fixation on a particular pattern reflected directly the relative time required to process that particular stimulus. It appears that eye movement patterns can provide information of a pragmatic nature such as: What does a poor reader look at in

comparison to a good reader? Are there priorities in attending to different parts of the visual array for good and poor readers? What words or parts of words attract poor readers in contrast to good readers?

The previous discussion leads to three basic conclusions. First, decentration of attention is a critical perceptual mechanism in the development of cognitive operations, that is, conservation. Second, conservation status appears to be related to reading skill attainment. Finally, eye movement studies provide reliable and objective information which may be beneficial in examining the reading process. Investigations into the nature of the reading process may be conducted more productively. Through an examination of perceptual-attentional differences between good and poor readers and how these differences relate to cognitive deficits, such as conservation misjudgement.

## Implications for Empirical Investigations

In line with the above, Mackworth specifically suggests using a corneal reflection eye movement camera to look at attentional behavior and pictorial-verbal processing in children. He maintains that reading studies which used a corneally reflected eye movement procedure could bring out the extent to which children were making mistakes in matching pictorial concepts with the verbal representation of the concept (1972). Subsequently, Mackworth (1971) suggests a task involving the matching of pictorial to verbal stimuli would establish the way in which children attend to the imaginal and symbolic features in a typical reading situation.

With respect to intervention approaches, a study by Wilton and Boersma (1974) used the Mackworth eye movement camera and demonstrated that attentional (centrative) behavior can be reliably studied by a corneally reflected eye movement procedure. The sample for the study consisted of 30 conservers (15 normals, 15 retardates) and 60 nonconservers (30 normals, 30 retardates). Nonconservers were randomly assigned to control or training group (conservation acceleration group). The results indicated that perceptual-attentional activity can be modified through shaping techniques which force children to look at relevant dimensions of stimuli.

In conclusion, corneally reflected eye movement procedures appear well suited for investigating types of perceptual-cognitive activities associated with learning to read. Furthermore, knowledge of such activities is especially crucial to current problems of diagnosis and remediation in reading. Mackworth (1973) notes the particular difficulty in assessing the attained skills of a child who is lacking in areas of language abilities. More specifically, he maintains that group testing procedures have served to screen behavior on a gross level of assessment. However, assessment of a reading achievement level may not be adequate in providing information as to the stage the child is at in learning to read, and what should sequentially come next in the development of necessary skills. Moreover, since school achievement is directly related to reading performance, areas of research promising information regarding the nature of the reading process must be thoroughly

explored.

## Summary and Objectives

In summary, reading is an area of educational and psychological interest about which there exists excessive research and insufficient information with respect to how children learn to read. Cognitive developmental theorists have provided an interesting framework from which perceptual and cognitive variables associated with the reading process may be investigated. Such a framework is directly adaptable to developmental remedial programs based on the deficiencies and differences exhibited by individual readers. From a review of the literature, it seems logical that techniques which accelerate perceptual-cognitive development should substantially affect reading performance. Furthermore, if these techniques were based on knowledge of particular strengths and weaknesses of individuals they should be even more effective. From the aforementioned, it would appear important that an investigation of reading in terms of two promising perspectives be considered.

First, as conservation acquisition is an important indication of conceptual development and has been related to initial reading skills, the assessment of conservation status in good and poor readers seems particularly basic to curriculum and intervention planning.

Secondly, eye movement analysis of informational search strategies and developmental patterns seems to be a useful way of examining differences in good and poor readers. An approach using corneal reflected

eye movement patterns could indicate whether poor readers are perceptually drawn to "appealing" pictorial stimuli, rather than efficiently decentering attention to other informationally relevant areas, such as verbal stimuli. An ultimate goal, if conservation status and efficiency of information search are found to be related to reading, would be the construction of remedial programs based on perceptual-attentional training.

In line with the above, cognitive developmental patterns of good and poor readers as assessed by Piagetian tests of conservation, will be investigated. In addition attentional-perceptual differences in the processing of pictorial and verbal stimuli, as measured using a corneal reflection eye movement technique, on the same children will be compared to the results of the conservation analysis.

## Basic Hypotheses

### Hypotheses for the Conservation Tasks

With respect to perceptual-cognitive processing, as assessed by Piagetian conservation tasks, it is surmised that there will be a greater tendency for poor readers to centrate on perceptually dominant aspects of the tasks. Accordingly, they will tend to make fewer correct judgements of conservation and will be less able to logically justify their responses.

Hypotheses of concern, with respect to possible differences on conservation attainment between good and poor readers are as follows:

1. Poor readers will give fewer conservation responses than good readers.

2. Poor readers will give fewer logical justification responses than good readers.

Hypotheses for the Eye Movement Tasks

In terms of the eye movement tasks, centration of attention will be most noticeable on aspects of the stimuli perceived as being perceptually dominant. It is surmised that poor readers will display more centrative behavior than good readers, and that this will be reflected by their performance on the task items, and by eye movement data. Due to the greater tendency to centrate, poor readers should take longer to break set and solve problems. In addition, they should find the picture-word identification task more complex than will good readers, and accordingly give fewer correct responses. The eye movement data should also differentiate the groups, with poor readers generally showing less efficient initial search strategies, less exploratory and comparative (between pictures and words) behavior than good readers. Correspondingly, poor readers should also spend more time examining specific elements of stimulus items.

From the above discussion the following hypothesis are postulated. Poor readers, in comparison to good readers will:

1. have a greater mean latency to response (take longer to respond).
2. make more errors (give fewer correct responses).
3. have greater diversity in location of initial fixation (reflecting less efficient initial search strategies in terms of left to right, top to bottom scanning.
4. have fewer fixations (thus reflecting less exploratory behavior, per unit of time).

5. have a longer mean length of fixation (reflecting a greater tendency to centrate).
6. make fewer couplings (reflecting a greater tendency to centrate on pictures, or on words, per unit of time).

# CHAPTER 3

# METHODOLOGY AND HYPOTHESES

## Method

### Subjects

A sample of 240 children were drawn from second grade classrooms in four Edmonton Public Schools. The schools served middle class populations. Subjects chosen for the study were those who demonstrated normal intelligence (according to teacher reports) had normal vision (as recorded on school medical records), and who showed no evidence of emotional disturbance (as detectable from school records and teacher interviews).

Good and poor readers were classified on the basis of results on the Gates MacGinitie Reading Test, Form B (1964). This test contains measures of both vocabulary and comprehension skills. Good readers were defined as those whose scores fell between one and two standard deviations above the sample mean whereas poor readers were defined as those whose scores fell between one and two standard deviations below the sample mean. From these groups, 25 good and 25 poor readers were randomly selected for further testing at the University of Alberta on conservation and eye movement tasks.

The final sample, however, consisted of only 15 good and 15

poor readers. This occurred because of eye movement machienery breakdown, as well as technical problems. Specifically, data on 8 subjects in the good reading group and 7 in the poor reading group were lost due to apparatus malfunction, which occurred after approximately 70% of the eye movement testing was completed. Information on another 5 subjects was lost due to technical difficulties. For example, one child could not be trained on the eye movement task; two oriental children had eyelids shaped such that a clear image of their pupil was unobtainable; one child wore glasses at the time of testing; and one child was too short for the specialized chair used in the eye movement task. Of these 5 subjects, 2 were good readers and 3 were poor readers. The previously mentioned difficulties resulted in smaller eye movement samples than originally anticipated, however since the subjects were randomly assigned for eye movement testing the problem probably effected both groups about equally.

The good reading sample consisted of 10 girls and 5 boys, whereas the poor reading sample contained 9 girls and 6 boys. Further testing of these groups indicated that they did not differ significantly with respect to chronological age, varying from 87 to 99 months for good readers, and from 84 to 98 months for poor readers.

Conservation data was collected and analyzed on these 15 good and poor readers. Eye movement data, however, was only

obtainable on 10 good (4 male and 6 female) and 10 poor (5 male and 5 female) readers as further informational losses occurred due to computer output problems during analysis. Thus, conservation data is based on 15 subjects per group, whereas eye movement data is only based on 10 subjects per group.

## General Procedure

The cooperation of the Edmonton Public School Board, the Principals of the four schools involved and the children's parents was first obtained. Then the children were transported to the University for testing by taxi, in groups of 2 or 3. Total time required for testing on Piagetian and eye movement tasks was approximately 1 hour, per child. This testing was conducted during the months of May and June, 1974. A random testing sequence was used to decide whether conservation testing was administered before the eye movement tasks or after. A rest period of about ½ hour was given between testing sessions.

## Conservation Task

Conservation status of individual subjects was established in terms of performance on the Concept Assessment Kit - Conservation (Goldschmidt and Bentler, 1968). This test provides standardized procedures for administering Piagetian conservation tasks, and normative data. Forms A and C of the test were administered, since together they appear to provide a more inclusive representation of tasks used by Piaget to assess conservation. Form A includes tasks

purporting to measure conservation of two-dimensional space, number, substance, continuous quantity, weight, and discontinuous quantity, whereas Form C includes tasks measuring area and length. A brief description of each task is presented in Appendix A.

Scoring and dependent variables.

Conservation behavior, indicating correct judgement of the relative quality of two objects, received one point. Comprehension of the principals of conservation, assessed by logical justification responses, received an additional point. Since Piaget (1950) maintains that competency in conservation is measured by a judgment as well as a logical explanation, a two point score was considered a true conservation response.

Conservation responses were recorded by a researcher familiar with Piagetian test procedures. Reliability of response classifications was assessed by having two independent judges score all the data. The inter-judge agreement was 99%.

The conservation dependent variables of concern are:

1. Number of conservation judgement responses - refers to the summated number of responses indicating conservation behavior.
2. Number of conservation explanation responses - refers to the summated number of logical justification responses on conservation tasks.

Conservation hypotheses.

Hypothesis 1:

It is surmized that, when compared on measures of conservation attainment, there will be statistically significant differences between good and poor readers. Specifically, poor readers will give fewer conservation responses and explanations than good readers.

Hypothesis 1.1 There will be statistically significant differences in the number of conservation responses, summed over subtasks (on Forms A and C) between good and poor readers, with poor readers giving fewer conservation responses. That is, poor readers will obtain fewer 1 point scores, in terms of the Golschmit and Bentler scoring procedure.

Hypothesis 1.2 There will be statistically significant differences in the number of logical justification responses, summed over subtasks (on Forms A and C) with poor readers giving fewer explanations of conservation. That is, poor readers will obtain fewer 2 point scores, in terms of the Goldschmit and Bentler scoring procedure.

## Eye Movement Task

Eye movement apparatus.

Eye movement variables were monitored and recorded by means of an infrared computer based oculometer designed and built by Honeywell, at their Radiation Center in Lexington, Massachusetts. This unit was modified and interfaced to a PDP8e computer at the University of

Alberta, Division of Educational Research Services (see Petruk, 1973, for a detailed discussion of this apparatus), so that 30 bits of eye movement information, per second, could be outputted onto computer tape for IBM 360 computer analysis.

The eye movement system included a source of infrared light, an infrared television camera, optical infrared light reflecting equipment, a variable intensity light source, a gelatin filter which blocked all but infrared light, and a computer interface unit. The system is based on the corneal reflection oculographic technique whereby the image of the eye is illuminated by infrared light and projected onto an infrared television camera which is connected to a computer. The image consisted of the illuminated pupil and the corneal reflection was converted by the camera into a video signal which outputted horizontal and vertical information at the end of every scan, relative to a time base. With respect to the present study, the displacement of corneal reflection, relative to the center of the pupil, indicated where the eye was looking.

Fixations were identified by means of programs developed for this purpose by the Division of Educational Research Services, University of Alberta. First, the format of the oculometer output was changed from that of the PDP8e to that acceptable to the IBM 360, and the X and Y coordinates for each complete scan of the eye were calculated. Then a program was used which clustered the coordinates (fixations) within an area approximately equal to plus or minus one half inch. In this program, as each coordinate occurred and was within a defined distance from the centroid of the previous coordinates, that

point was added to the previous points for purposes of defining the fixation. If the point was beyond the distance specified, it became the basis for definition of a new fixation. Means and standard deviations of the points clustered were calculated, which defined the fixation in terms of average X and Y coordinates, and indicated the variability of the locations of points within the cluster.

Stimulus material was displayed on a 10" by 10" screen, approximately 16" from the eye of the subject. A 16mm projector, controlled by an IBM 1500 CAI system, presented single stimulus frames according to a random programmed sequence, which allowed for individual response latencies to be recorded without disruption of the testing session. After briefly familiarizing the subject with the equipment the subject's head was positioned using a chin rest and head stabilizers which restrained movements from side to side. The headrest and chair were then adjusted until the image of the pupil and corneal reflection were clearly focused on a video monitor.

Pictorial-verbal matching task

A pilot study was conducted to ascertain the level of difficulty required for the pictorial and verbal matching task. This was necessary to decide how complex items should be in order to discriminate between good and poor readers. Twelve grade two children were tested individually in a private room at an Edmonton Elementary school. The experimenter was unaware of the order of testing of good and poor readers. The children were tested on three levels of complexity of pictorial and verbal elements, specifically, easy, medium and difficult (see Appendix B for a description of the pro-

cedure used to classify stimulus items according to these three levels of difficulty). The results, presented in Appendix C, indicated that three stimulus items consisting of four difficult pictures and four difficult words each, best discriminated between good and poor readers. Consequently, eye movement data collected on the three items classified as containing difficult pictorial and difficult verbal elements were utilized for the present study.

Figure 1 presents the actual stimulus material. A correct response on the top item was considered to be one which matched the first picture with the word "surprise". In the middle item, the third picture was to be matched with the word "police" and on the last item the second picture and the word "entrance" were considered to go best together.

The subjects were trained to close their eye when they found the word and picture that went together best on four trial items. After the subjects had their eyes closed for approximately 5 seconds they were asked to open their eyes and to point to the word and picture that they had chosen. The children were given verbal feedback as to the correct responses on the trial items. On task items however, they were told that their responses were "good answers" regardless of correctness.

<u>Scoring and dependent variables.</u>

Using printouts of the program which clustered eye coordinates, plots of eye fixations were drawn manually. This program was also used to determine data for the eye movement variables (see Appendix D

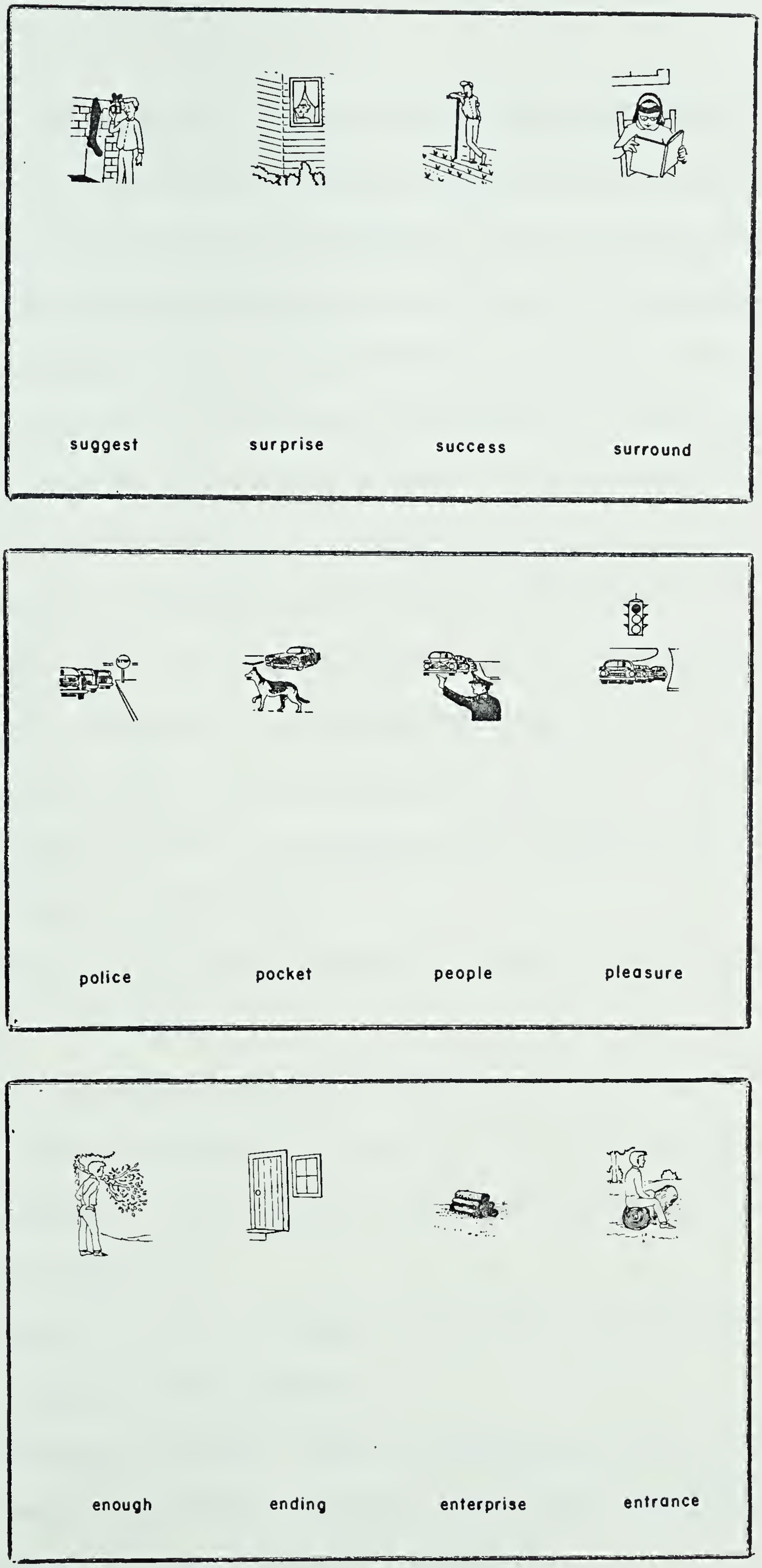


Figure 1. Stimulus material

for a detailed description of this scoring procedure). Only the first three seconds of eye movement data were scored for each subject, since recent eye movement studies have indicated that this time base allows for the collection of an adequate, but not overwhelming amount of data (O'Bryan and Boersma, 1971 and Wilton and Boersma, 1974). As a check on the accuracy of the scoring procedure two judges independently scored ten protocols, selected at random. The inter-judge agreement for these recorders was 97%, thus indicating high reliability of the scoring system. An additional check was run on number of unscoreable frames to determine whether or not this variable differentially affected the two groups. It was found that there was no statistically significant difference between the groups for number of unscoreable frames ($t=.278$, $df=18$ ns), and specifically, that about 8% of the frames were unscoreable in each group.

The following eye movement terms were used to define the dependent variables for this task.

1. Unit of time - refers to the first three seconds of exposure to stimulus material, measured in 1/30 second units. All appropriate eye movement variables were scored relative to this time base.
2. Element - refers to either the verbal or pictorial part (element) of the stimulus.
3. Intraelement unit - refers to components within either the verbal or pictorial elements. The verbal and pictorial elements always contained 4 parts.

4. Fixation - refers to the point at which the subject concentrated his gaze for a minimum of 1/30 of a second during eye movement recording. A consecutive eye movement change greater than approximately ½ inch (i.e., within an area subtended by about 1 degree of arc at a distance of 16 inches) was considered to be a change in fixation.

Dependent variables of concern for the present study were:

1. Mean latency of response - refers to the amount of time in 1/30 second units taken to respond to the task, i.e., to eye closure.
2. Number of errors - refers to the total number of incorrect responses.
3. Position of initial fixation - refers to the location of the first fixation in terms of upper left, upper right, lower left and lower right quadrants.
4. Number of fixations - refers to the total number of changes in fixation (plus one) on pictorial or verbal elements, or summed over both elements.
5. Mean length of fixation - refers to the ratio of the summated number of 1/30 of a second periods to the total number of fixations made on either pictorial or verbal elements, or summed over both elements.
6. Number of couplings - refers to the number of changes in fixation between verbal and pictorial elements, i.e., the number of between element comparisons.

Eye movement hypotheses.

Hypothesis 2:

It was surmized that when compared on the pictorial-verbal matching task, there would be statistically significant differences between good and poor readers. Specifically, poor readers will demonstrate more centrative behavior in terms of performance and eye movement variables.

Performance hypotheses

Hypothesis 2.1 There will be statistically significant differences in terms of the length of time taken to respond to the pictorial-verbal matching problem, with poor readers requiring more time to reach a solution.

Hypothesis 2.2 There will be statistically significant differences in terms of the number of errors made in pictorial-verbal matching problems, with poor readers giving fewer correct responses.

Corneally reflected eye movement hypotheses

Hypothesis 2.3 There will be statistically significant differences in terms of the location of initial fixation, with poor readers showing less efficient initial search strategies. In terms of left-right, top-bottom scanning, poor readers will begin their visual search in the upper left and right quadrants of the viewing field less often than good readers.

Hypothesis 2.4 There will be statistically significant differences in terms of the number of fixations with poor

readers making fewer fixations, per unit of time.

Hypothesis 2.5 There will be statistically significant differences in terms of the mean length of fixation, with poor readers being less able to break set and further explore the stimulus, per unit of time.

Hypothesis 2.6 There will be statistically significant differences in terms of the number of couplings, with poor readers making fewer picture-word comparisons per unit of time.

Statistical Analyses

Conservation data were analyzed statistically, while eye movement tasks were treated statistically and graphically. Conservation and eye movement hypotheses were tested by means of chi-square analysis (Ferguson, 1971) and independent *t* tests (Ferguson, 1971). To further clarify the eye movement findings, graphic representations were made of the interactions between pictorial and verbal variables.

# CHAPTER 4

## RESULTS

The findings are presented in two sections. In the first section the data pertinent to the major conservation hypothesis is analyzed. There are two subhypotheses discussed in this section. The data pertinent to the major eye movement hypothesis is analyzed in the second section. Six subhypotheses are included in this discussion.

Analysis of Conservation Hypotheses.

Hypothesis 1, that good and poor readers would differ in terms of measures of conservation attainment was supported. This hypothesis was examined by comparing conservation responses for Forms A plus C (total scores), and separately, for Forms A and C. Table 1 presents mean and $t$ values for good and poor readers as a function of type of response. All comparisons were statistically significant in terms of differences between good and poor readers.

More specifically, hypothesis 1.1, that poor readers would give fewer conservation responses, i.e., obtain fewer 1 point scores in terms of Goldschmit and Bentler's scoring procedure, was supported. Here poor readers demonstrated significantly less conservation behavior, than good readers, on Form A ($t=2.75$, $df=28$, $p<.01$), Form C ($t=2.17$, $df=28$, $p<.05$) and Forms A plus C ($t=2.44$, $df=28$, $p<.05$).

Hypothesis 1.2, that poor readers would give fewer explanation responses (logical justifications) i.e., obtain fewer 2 point scores in terms of Goldschmit and Bentler's scoring procedure, was also

supported. Poor readers in comparison to good readers, gave fewer logical justification responses on Form A ($t=3.55$, $df=28$, $p<.001$), Form C ($t=4.94$, $df=28$, $p<.001$), and Forms A plus C ($t=4.75$, $df=28$, $p<.001$).

Thus, the data in Table 1 reveals distinct differences between good and poor readers for all comparisons. More subjectively, it appears that good - poor reader differences are greater in terms of logical justification responses, and that Form C is more difficult than Form A, since lower mean values are associated with this form.

To investigate, in more detail, possible differences between good and poor readers, in terms of ability to give logical justifications in comparison to conservation responses, a _t_ test was run on conservation and logical justification response difference scores between groups. This analysis revealed that poor readers in comparison to good readers, were less able to justify their responses ($t=4.405$, $df=28$, $p<.001$). Thus, poor readers not only gave fewer conservation responses, they also had more difficulty explaining the reasons behind their responses.

Since Forms A and C were originally chosen because Form A contained the conservation of weight task and Form C contained tasks measuring conservation of length and area (tasks supposedly occurring at latter stages of cognitive developtment), performance on individual items was also analyzed. This analysis involved chi-square tests using 2x2 contingency tables (conserver-nonconserver x good - poor readers) to ascertain which subtasks best differentiated good and poor readers. Table 2 presents the chi-square analyses for individual

Table 1

Mean Number of Conservation and

Logical Justification Responses

| Comparison | Mean Good Reader | Mean Poor Reader | t* | p |
|---|---|---|---|---|
| Form A | | | | |
| Conservation Responses | 5.80 | 4.87 | 2.75 | .005 |
| Justification Responses | 5.53 | 3.93 | 3.55 | .000 |
| Form C | | | | |
| Conservation Responses | 5.20 | 4.00 | 2.17 | .019 |
| Justification Responses | 4.93 | 2.67 | 4.94 | .000 |
| Form A+C (Total) | | | | |
| Conservation Responses | 11.00 | 8.93 | 2.44 | .011 |
| Justification Responses | 10.47 | 6.60 | 4.75 | .000 |

*df=28

Table 3

Between Group Comparisons on Individual Conservation on Items

| | | Conservation Response | | Logical Justification | | $\chi^2$ Conservation Response | $\chi^2$ Logical Justification |
|---|---|---|---|---|---|---|---|
| Subtask | Groups | C | NC | C | NC | | |
| Form A | | | | | | | |
| Two Dimensional Space | GR | 15 | 0 | 14 | 1 | 1.03 | 3.33 |
| | PR | 14 | 1 | 10 | 5 | | |
| Number | GR | 15 | 0 | 13 | 2 | 1.03 | 2.73 |
| | PR | 14 | 1 | 9 | 6 | | |
| Substance | GR | 15 | 0 | 14 | 1 | 2.14 | .83 |
| | PR | 13 | 2 | 12 | 3 | | |
| Continuous Quantity | GR | 15 | 0 | 15 | 0 | 1.03 | 2.14 |
| | PR | 14 | 1 | 13 | 2 | | |
| Weight | GR | 12 | 3 | 12 | 3 | 8.57** | 8.57** |
| | PR | 4 | 11 | 4 | 11 | | |
| Discontinuous Quantity | GR | 15 | 0 | 15 | 0 | 1.03 | 6.00** |
| | PR | 4 | 11 | 4 | 11 | | |
| Form C | | | | | | | |
| Area I | GR | 13 | 2 | 13 | 2 | .24 | .24 |
| | PR | 12 | 3 | 12 | 3 | | |
| Area II | GR | 12 | 3 | 12 | 3 | .186 | 1.428 |
| | PR | 11 | 4 | 9 | 6 | | |
| Area III | GR | 9 | 6 | 7 | 8 | 1.2 | 2.4 |
| | PR | 6 | 9 | 3 | 2 | | |
| Length I | GR | 15 | 0 | 15 | 0 | 3.33 | 15.00** |
| | PR | 12 | 3 | 5 | 10 | | |
| Length II | GR | 15 | 0 | 15 | 0 | | |
| | PR | 11 | 4 | 4 | 11 | .46 | 17.368** |
| Length III | GR | 14 | 1 | 12 | 3 | | |
| | PR | 9 | 6 | 7 | 8 | 4.658* | 3.58 |

C - Refers to Conserver
CN - Refers to Nonconserver

* p .05
** P .01

items.

On Form A only two conservation tasks differentiated between good and poor readers. These tasks were weight and discontinuous quantity. On the conservation of weight task, poor readers gave fewer conservation responses ($\chi^2$=8.57, df=1, p<.01) and fewer logical justifications ($\chi^2$=8.57, df=1, p<.01). The discontinuous quantity task however only separated the groups in terms of logical justification responses ($\chi^2$=6.00, df=1, p<.05). Thus the weight and discontinuous quantity tasks best differentiated good and poor readers. The weight task differentiated as expected, whereas the discontinuous quantity task results were not anticipated from the literature.

Form C, which was divided into three area and three length tasks, only differentiated between the groups in terms of conservation of length. With respect to conservation of length performance, differences between the groups were noted in terms of conservation of length performance, differences between the groups were noted in terms of conservation responses on one task ($\chi^2$=4.658, df=1, p<.05) and logical justifications on two tasks, ($\chi^2$=15.00, df=1, p=<.001) ($\chi^2$=17.37, df=1, p=<.001) respectively. Consequently conservation of length seems particularly suitable in terms of differentiating good and poor readers.

In summary, the data revealed that on both Forms A and C of the Goldschmid and Bentler conservation test between group differences were noted, particularly on weight, discontinuous quantity and length tasks. It should be noted however, that although an

overall effect was observed between the groups, that only 3 of the 12 subtasks differentiated between good and poor readers. This indicates that the data should be considered with this qualification.

Analyses of eye movement hypotheses.

Hypothesis 2, that when compared on a pictorial-verbal matching task, poor readers would demonstrate more centrative behavior in terms of performance and corneally refelcted eye movement variables, was generally supported. Specifically, with respect to differences between good and poor readers, five of the six subhypotheses received some statistical support.

Performance hypotheses.

The first variable of concern here is response latency. Hypothesis 2.1, suggested that poor readers would require more time to reach solution on the picture-word matching task. This hypothesis was supported in that poor readers took approximately twice as long, on the average, to respond to the problems ($t=2.071$, $df=18$, $p<.05$). More specifically, good readers decided which picture and word went "best" together in approximately 10.44 seconds, whereas poor readers required about 20.26 seconds.

Hypothesis 2.2, that poor readers would give fewer correct responses than good readers was also supported. Here poor readers had statistically fewer correct responses on the pictorial-verbal matching problems than good readers ($t=3.60$, $df=18$, $p<.05$). Mean number of correct responses for good readers was 2.46 while it was only 1.20 for poor readers.

The above findings indicate that poor readers, in comparison to good readers, found the eye movement task more difficult than did good readers. This was noticeable in two ways. First, poor readers required more time to process the pictorial and verbal information, and secondly, even after taking more time to make their response, poor readers made more incorrect decisions. Analysis of corneally reflected eye movement data were undertaken to further clarify differences between groups on this task.

Corneally reflected eye movement hypotheses.

Hypothesis 2.3, that poor readers would display less efficient initial search strategies in terms of left to right, top to bottom, visual scanning, was tested first. An efficient search strategy was considered to be one which would demostrate, by the location of the initial fixation, a tendency to begin scanning in the upper quadrants, particularly the upper left quadrant. An inefficient strategy then would be the antithesis of this strategy, that is, one which began in the lower quadrants, particularly in the lower right quadrant. Table 3 presents frequency of initial quadrant search for poor and good readers, along with appropriate chi-square statistics.

Comparisons of frequencies of initial fixations within quadrants indicated that poor readers did not demonstrate significant differences in terms of locations of initial fixations within any of the quadrants ($\chi^2$=.70, df=1, ns). There was a tendency, however, for poor readers to initially look at the left quadrants, particularly the lower left quadrant. There were also several instances of poor readers initially

Table 3

Frequency of Initial Quadrant Search For Good and Poor Readers

| Groups | Elements | Left | Right | |
|---|---|---|---|---|
| | Pictures | 10 | 10 | |
| Good Readers | | | | 5.81* |
| | Words | 10 | 0 | |
| | Pictures | 11 | 1 | |
| Poor Readers | | | | .70 |
| | Words | 13 | 5 | |

* p .05

fixating in the bottom right quadrant. Thus, it appears that poor reader's initial response is more often drawn towards words than pictures.

Good readers, on the other hand, did differ significantly in terms of expected within cell frequencies of quadrant of initial fixation ($\chi^2=5.81$, df=1, $p<.05$). Specifically, good readers initially fixated in the upper quadrants 66.66% of the time, while the remaining 33.33% of fixations occurred in the lower left quadrant. It is important to note that there were no instances of good readers beginning visual search of the stimulus material in the lower right quadrant.

In short, it appears that within the good reader group, the left-right, top to bottom, search strategy was better established, than within the poor reader group. Moreover, this strategy is assumed to be a more efficient means of processing visual information. Poor readers were attracted to verbal elements more frequently than they were to pictorial elements suggesting that verbal elements were perceived as being more perceptually dominant. It might further be surmised that poor readers tend to centrate on words at the expense of better informational processing strategies. In fact, an examination of number of scoreable frames, spent on pictorial or verbal elements, per three second time base, for good and poor readers supported this supposition. Here good readers fixated on pictures and words for almost an equal number of frames, 50.42% and 49.58% respectively, whereas poor readers fixated on pictures for 38.65% of the frames and 61.35% of the frames were on words.

Table 4

Between Group Comparisons on Eye Movement Data

| Variables | Mean Good Reader | Mean Poor Reader | t* | p |
|---|---|---|---|---|
| Total Number of Fixations | 37.90 | 33.60 | .821 | .2113 |
| Number of Fixations on Pictures | 18.40 | 12.70 | 2.117 | .0242* |
| Number of Fixations on Words | 16.60 | 18.20 | .491 | .3147 |
| Total Mean Length of Fixation | 7.60 | 9.39 | 1.568 | .0671 |
| Mean Length of Fixation on Pictures | 7.85 | 7.69 | .143 | .4441 |
| Mean Length of Fixation on Words | 8.08 | 12.10 | 1.952 | .0334* |
| Total Number of Couplings | 9.40 | 8.10 | .861 | .2004 |

*df=18

Table 4 presents means and t values relevant to hypotheses 2.4, 2.5, and 2.6. In interpreting this eye movement data it should be remembered that all statistical comparisons are based on the first three seconds of exposure. Appendix E gives actual raw scores for these variables.

Hypothesis 2.4, that poor readers would have fewer fixations than good readers per 3 second time base, was supported with respect to total number of fixations on the pictorial element ($t=2.117$, $df=18$, $p<.05$). Here poor readers made half again as many, or about 18.40 fixations. There were no statistically significant differences in terms of number of fixations on verbal elements ($t=.491$, $df=18$, ns) or summed over both elements ($t=.821$, $df=18$, ns) between groups.

Figure 2 represents graphically the above findings. It can be noticed that whereas good readers had slightly higher mean number of fixations on pictures (18.40) than on words (16.60), poor readers had considerably fewer fixations on pictures (mean number=12.70) than on words (mean number=18.20).

It thus appears, that although good readers look at the pictorial element more often than poor readers, they do not differ significantly from poor readers in terms on number of different examinations (fixations) on the verbal element, of summed over both elements. This finding is consistent with the quadrant observation that good readers begin visual search, more often on the pictorial element, and continue to fixate on the pictorial element more frequently than poor readers. In addition, the above indicates that poor readers

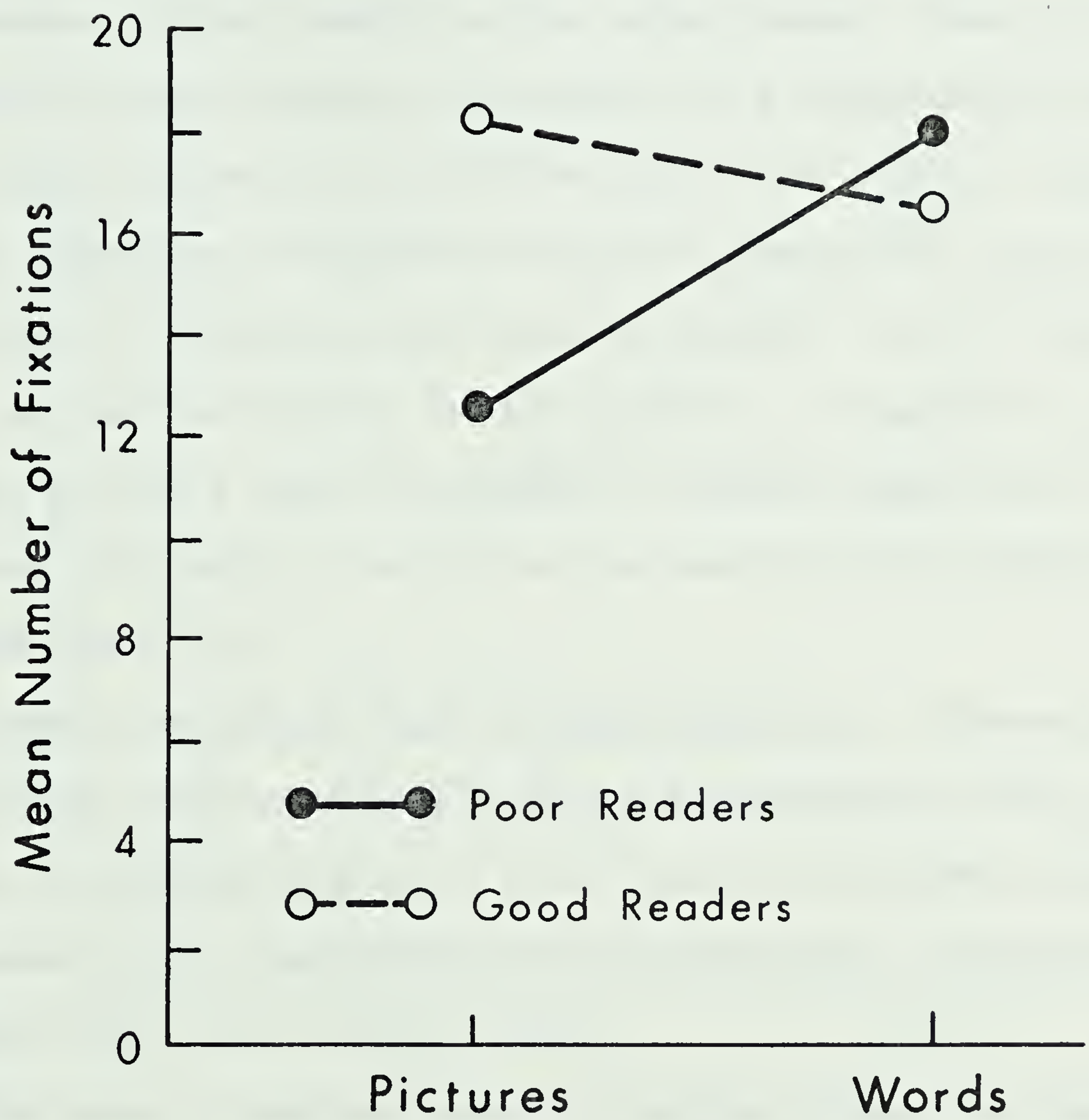


FIGURE 2. BETWEEN GROUP COMPARISONS OF MEAN NUMBER OF FIXATIONS ON PICTURES AND ON WORDS

are initially attracted to verbal elements more often and tend to centrate on words.

Hypothesis 2.5, that poor readers would be less able to break set as reflected by a longer mean length of fixation, was supported with respect to this variable on the verbal element. Here, in comparison to good readers, poor readers had a significantly longer mean length of fixation on words ($t=1.952$, $df=18$, $p<.05$). There were no significant differences between the groups with respect to mean length of fixation on the pictorial element ($t=.143$, $df=18$, ns). But a tendency was observed for poor readers, in comparison to good readers, to have a longer mean length of fixation summed over both elements. This effect, however, was not statistically significant ($t=1.568$, $df=18$, ns).

Figure 3 represents these findings graphically. Observation of this figure reveals that good readers had approximately equal mean lengths of fixation on pictures (7.85) and on words (8.08), whereas poor readers had a considerably shorter mean length of fixation on pictures (7.69) than on words (12.10).

The above is consistent with the previous finding that poor readers are initially attracted to verbal elements, and consequently, spend more time processing verbal information. Moreover, it is not surprizing to observe that poor readers spend more time on stimuli which are hard for them, viz. words.

Hypothesis 2.6, that there would be significant differences in terms of the number of couplings (between element shifts) was not

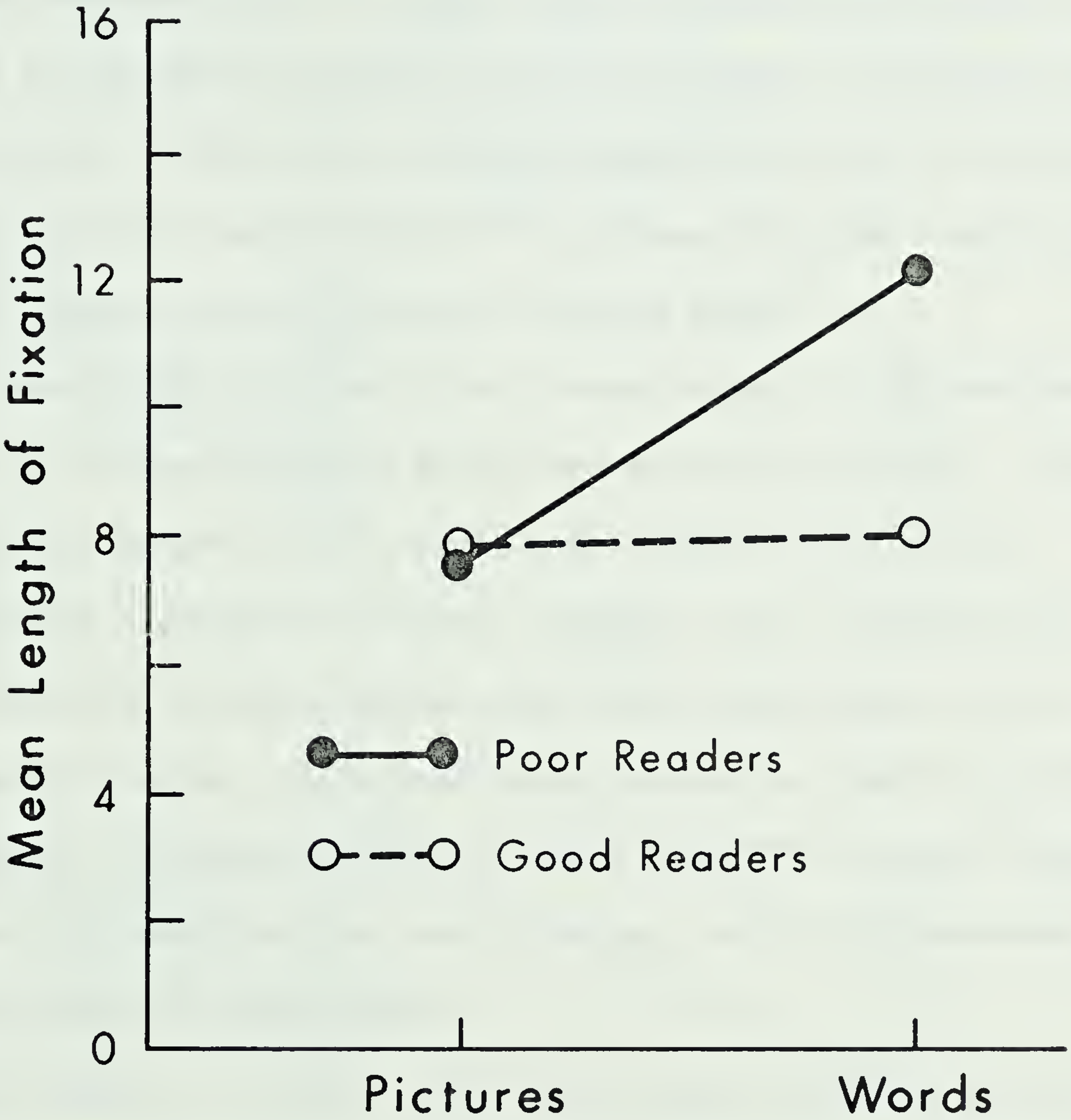


FIGURE 3. BETWEEN GROUP COMPARISONS OF MEAN LENGTH OF FIXATION ON PICTURES AND ON WORDS

supported statistically (t=8.61, df=18, ns). It is important, however, to note that there was a tendency for poor readers to make fewer pictorial-verbal comparisons than good readers (mean poor readers=8.10; mean good readers=9.40). A larger sample probably would have contri= buted to a significant coupling effect here since one subject appears to have unduly inflated the coupling scores for the poor reader group. Specifically, this subject made 17 couplings which was 7 more than the next highest score in the poor reading group.

Figures 4 and 5 present plots, respectively, of eye movement patterns of a "typical" good (S-15) and poor reader (S-13). These subjects were chosen in that their data tended to reflect the statistically significant effects. Figures 6 and 7 graphically extend the data on these subjects to a total time base, and are presented to generate additional suppositions for visual processing differences. It should further be noted that "S" in their figures represents the start of the search pattern, while "F" represents the termination or finish point.

With respect to Figure 4, the good reader initially fixated on the upper left quadrant, that is the pictorial element. Visual search progressed from one picture to another and then shifted to the verbal element. Here the reader fixated on two words, including "surprise", which was the important (correct) word for solving this matching problem. Search was next shifted back to the pictorial element and the subject investigated the remaining pictures. Thus, in the first three seconds of exposure, the good reader examined all

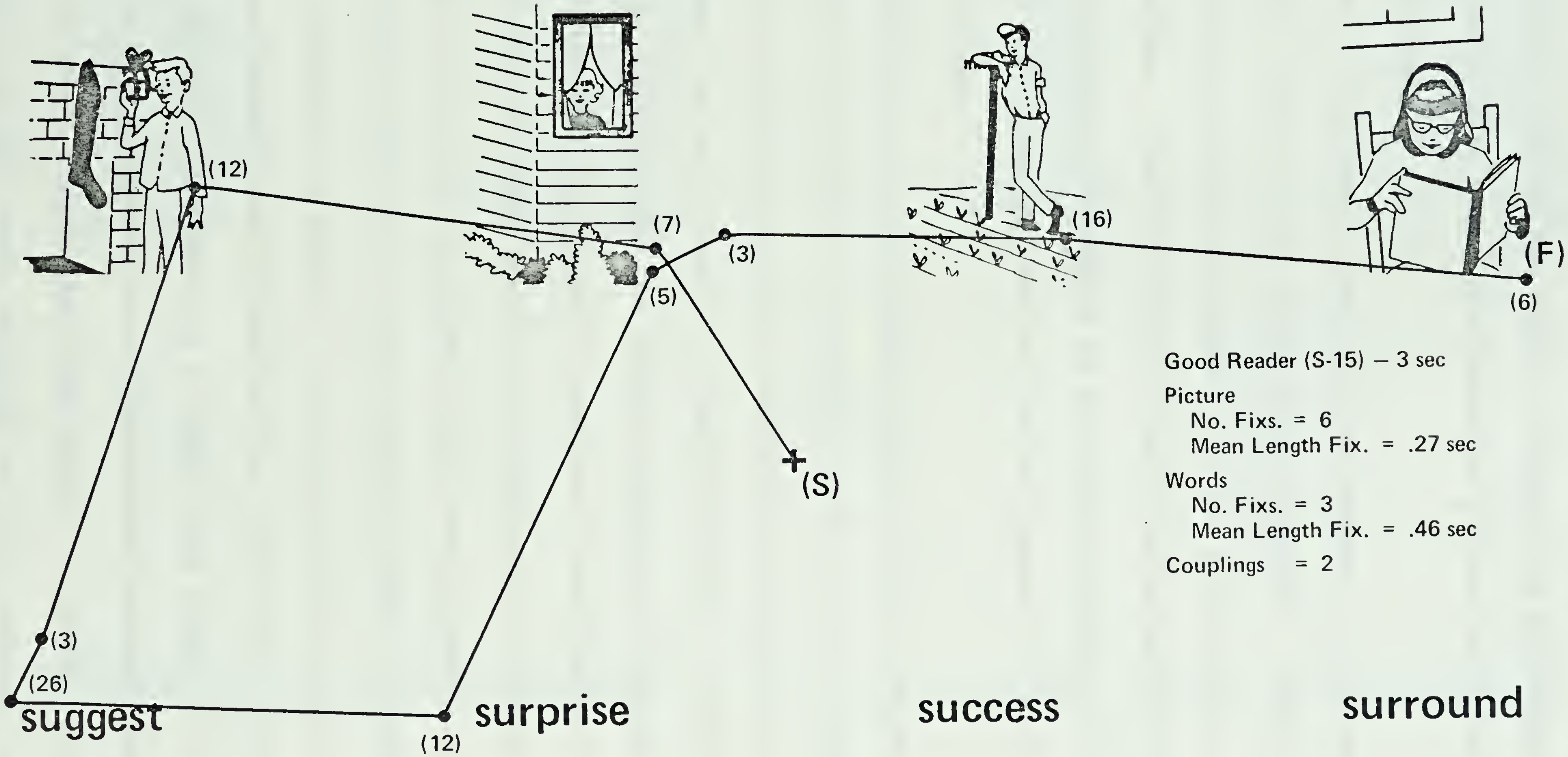


Figure 4. Plot of a Typical Eye Movement Pattern for a Good Reader on the First Three Seconds of Exposure

of the pictures, two of the words, and made two couplings. In addition, up to this point the important picture and word for this item were examined.

Figure 5 illustrates that the poor reader, on the other hand, began visual search in the bottom right quadrant. Intraelemental comparisons were then made between 3 of the 4 words with no couplings being observed. Therefore in the first three seconds of exposure the poor reader centered attention on the verbal element, to the exclusion of the pictorial element, and yet did not appear to fully investigate all of the words.

A comparison of total exposure time for these subjects is particularly interesting (cf. Figures 6 and 7). For example, the good readers solved the problem correctly in one-half the time it took the poor reader to come to a decision which was incorrect. Moreover, it appears that the correct decision was derived from a systematic and efficient search strategy. Specifically, Figures 6 and 7 show that the good reader, in comparison to the poor reader, examined all of the intraelemental units more quickly, and in addition, made more than twice as many between element comparisons.

With reference to Figure 7, the poor reader looked at the verbal element considerably more often than the pictorial element, as reflected by more fixations and a longer mean length of fixation on words. The search pattern here depicts more frequent comparisons from word to word, rather than from picture to word. In fact, the poor reader made only three couplings in 15.4 seconds. In

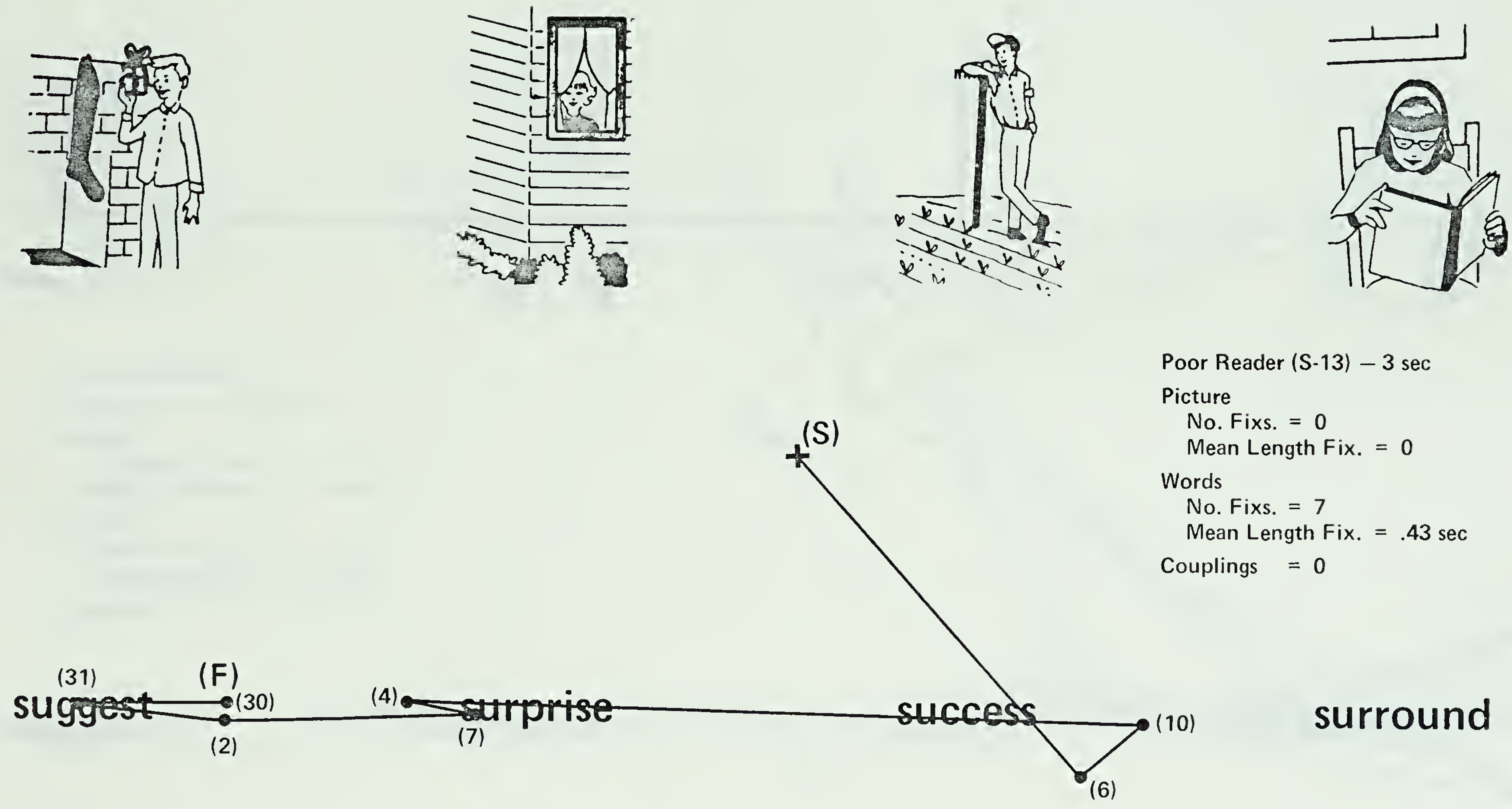


Figure 5. Plot of a Typical Eye Movement Pattern for a Poor Reader on the First Three Seconds of Exposure

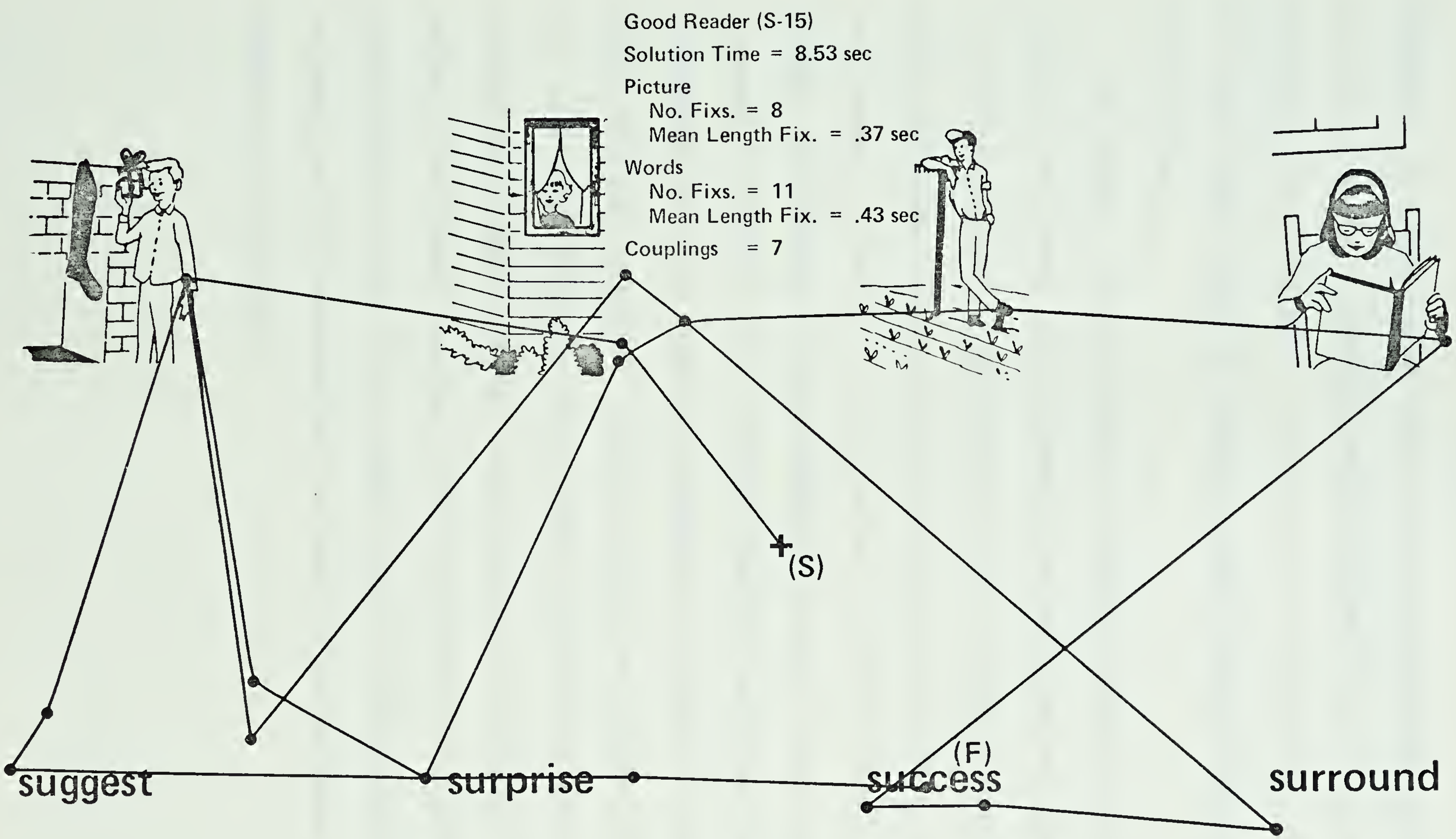


FIGURE 6. PLOT OF A TYPICAL EYE MOVEMENT PATTERN FOR A GOOD READER ON A TOTAL TIME BASE



62.

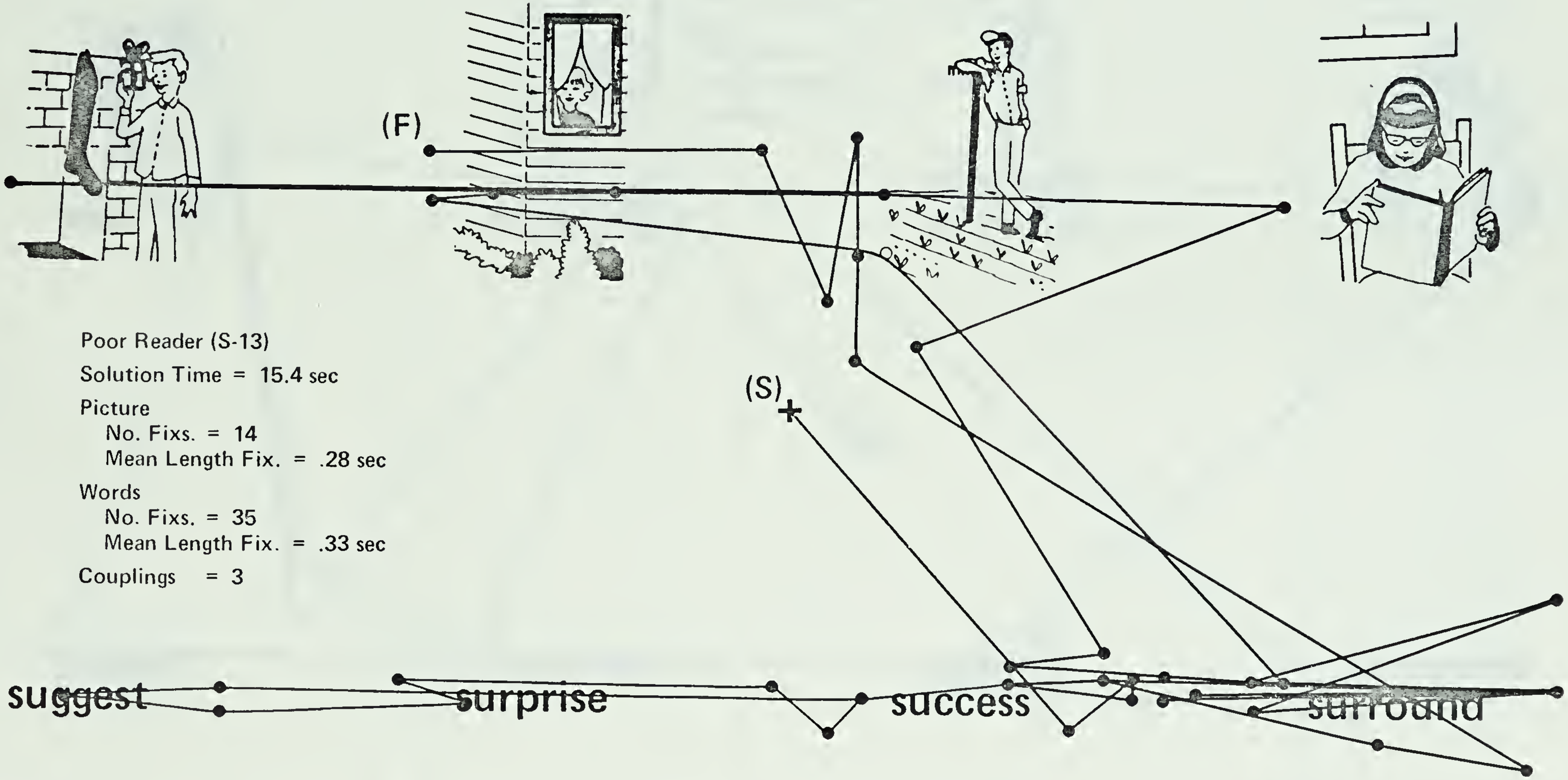


FIGURE 7. PLOT OF A TYPICAL EYE MOVEMENT PATTERN FOR A POOR READER ON A TOTAL TIME BASE


63.

addition, it appears that there were more fixations on two words, in comparison to the others, which suggests that these words may have been more difficult. Finally, it is interesting to note that the poor reader chose an incorrect match between pictures and words on this item.

In summary, the eye movement findings reported in this section indicate that there are differences between good and poor readers on several measures. Specifically, poor readers found the pictorial-verbal matching task more difficult than good readers, in that they took longer to decide on a picture-word match and tended to make more errors. In addition, when looking at stimulus items, poor readers appeared to utilize less efficient search strategies, spend more time processing verbal elements, and looked at pictorial elements less often than good readers. The fact that poor readers spent more time on a particular element, viz., words; less time on the pictorial element and tended to make fewer couplings, all suggests that such subjects are indeed showing a form of centrative behavior. Specifically, they appear to look at the element which is perceptually more dominant for them, as did nonconservers in previous eye movement studies of conservation behavior.

CHAPTER 5

# DISCUSSION AND CONCLUSIONS

## Objective

The major objective of this study was to determine whether perceptual-conceptual differences between good and poor readers could be identified on the basis of measures of conservation status, as well as in terms of eye movement patterns on a reading related task. The findings suggest that there are, indeed, perceptual-conceptual differences between good and poor readers on these tasks.

## Conservation and Eye Movement Results

Poor readers were found to demonstrate less conservation behavior than good readers. These differences were noticeable in two ways. First, poor readers, in comparison to good readers, made fewer conservation responses, and secondly, they failed to give justifications for conservation responses to the extent that good readers did. Logical justifications are considered to be the confirmation of conservation acquisition. It was also noted that the more complex conservation tasks, as suggested by the literature, viz., length and weight, best differentiated between the groups. Differences between groups were also noted on the discontinuous quantity task, although this findings was unexpected in terms of the literature.

In general, poor readers tended to give phenomenological explanations (such as, "when the ball is flat it's not as heavy but

when it's round it has more weight" or "cause it's a circle"), whereas good readers were more likely to logically support their responses with emperical referents (such as, "it is just flattened out, you didn't take any away" or explained that "before it was a ball; in any shape it still weighs the same"). This suggests that poor readers may be unable to identify important dimensions within a stimulus complex to the extent that good readers do.

Further group differences were observed on the eye movement task. Here poor readers took about twice as long as good readers to match pictures to words, and still made significantly more errors. It also appears that while good readers frequently used a left to right, top to bottom, search strategy, poor readers did not. In fact, poor readers often began visual search in the bottom half of the stimulus field, and even occasionally from the bottom right hand corner. There was also a tendency for poor readers to make more intraelement comparisons than good readers, and fewer interelement couplings. In addition, it was apparent, both statistically and graphically, that poor readers fixated on pictures less often and tended to centrate visual search on words.

When a total time base was utilized to present the data of a good and a poor reader, perceptual-attentional differences were more noticeable. Here the poor reader looked most often at two words, presumably those which were perceived as difficult, rather than distributing attention more equitably.

Several suppositions can be drawn from the above eye movement findings with regard to reading tasks involving illustrative and

textual material. For example, there may be differential attentional priorities in examining parts of a visual array for good and poor readers. More specifically, poor readers may primarily attend to verbal elements (words which they find difficult) whereas good readers may be more explorative in their search. Thus pictorial material may end up being of little help to poor readers in terms of keeping their interest and/or helping them to identify words with pictures. This may be due, in part, to the fact that the perceived complexity of difficult words attracts poor readers unduely to the extent that they fail to finish processing information which they can read. For example, in the present study the poor reader (cf. Figure 7) spent the major portion of his time on the words <u>success</u> and <u>surround</u>, and does not appear to have found the correct word, <u>surprise</u> difficult. Yet he still failed to identify the correct picture.

Conservation findings are in agreement with two conservation-reading studies discussed previously. Hurta (1972) and Johnson (1972) both empirically investigated the relationship between conservation and reading, and found that poor readers were significantly less able to judge and explain conservation than were good readers. Hurta's results are of particular interest as she too utilized the Goldschmid and Bentler test to ascertain conservation status in good and poor readers. Although the poor readers in Hurta's sample were remedial class students and were receiving assistance for reading difficulties, she similarily found that length, and to a lesser extent weight, best discriminated between groups. Unlike the present study, she also

found a tendency for poor readers to have difficulty on the conservation of substance task. With respect to the present study, it should be noted that only 3 of the 12 conservation tasks actually differentiated between the groups. Thus generalizations regarding good and poor reader differences on conservation tasks should be made with caution.

In terms of eye movement data, the present findings appear to be in agreement with studies investigating the relationship between conservation status and eye movement behavior. Specifically, O'Bryan and Boersma (1971) found that nonconservers fixated attention on irrelevant, but perceptually appealing aspects of conservation tasks, noticeably the element which was perceived as being larger (the transformed element). These authors suggested that since nonconservers made fewer runs (consecutive fixations on an element) and couplings (between element shifts in fixation) that nonconservers were utilizing a less comparative visual search strategy. These conclusions seem to explicate the current results in that centration of attention may be inhibiting poor readers in processing relevant information on both the conservation and eye movement tasks. This may especially be the case on the pictorial-verbal matching task since it was designed in such a manner that similar variables to those measured by the O'Bryan and Boersma study could be identified. For example, pictorial and verbal elements were sufficiently separated that couplings could be easily recognized.

The theoretical positions previously noted provide for meaningful

interpretations of the current findings. For example, to recapitualate briefly, Piaget (1950) emphasized the importance of perceptual activity to cognitive development in that he suggested that perceptual errors, and consequently, cognitive misinterpretations, were the result of centrative attention. More specifically, centration is considered to be a mechanism which produces systematic distortion due to fixation on a dominant element. This position implies that poor readers may be caught in a similar situation. To begin with, poor readers may be initially drawn to the verbal element. They may then centrate on the difficult word(s) which results in yet greater perceptual distortion, i.e., the word(s) may become even more overwhelming. Due to the amount of time spent on such words they may be unable to attend to words that are actually familiar and could provide sufficient information to solve the task, or perhaps get the meaning of a written passage.

The present findings, do in fact, support the above position. Poor readers demonstrated more conservation misjudgements and centrative type eye movement patterns. Good readers, on the other hand, made more correct conservation judgements, demonstrated more systematic search strategies, and processed information more quickly. In line with this, O'Bryan and Boersma (1971), as well as Wilton and Boersma (1974), have reported that nonconservers do indeed show centrative behavior. Thus in the present study, it is not surprising to find that poor readers (who also tend to have more difficulty on conservation tasks) show a type of centrative behavior. It is

interesting at this point to examine two additional theoretical explanations which may assist in clarifying the data of the present study.

Wohlwill (1968) has suggested that cognitive processing develops with the increasing stability of concepts, in spite of perceptually attracting but irrelevant changes. This position also proves helpful in discussing the present findings in that fewer correct responses and more phenomenological explanations were given by poor readers, suggesting that conservation concepts were not as well established for them as for good readers. In line with this the data also suggests that poor readers, even those who may have been transitional conservers (could judge but could not explain conservation), may have been more distracted by perceptually dominating aspects of the stimulus material.

Mackworth's (1972) position closely parallels the preceding theoretical suppositions. He believes that poor readers' attention is still being controlled by the nature of stimulus features. Furthermore, he has suggested that an eye movement study of where children look when presented with a picture-word matching task would indicate possible sources of processing difficulties.

The present comparison of eye movement patterns of good and poor readers on a task similar to the type suggested by Mackworth reveals data supportative of his hypothesis. For example, significant differences were found between the groups in terms of approaches to the task, with poor readers seemly less prepared for analysis of informationally important areas of the visual field. In fact, it

appears that poor readers were initially drawn to the verbal element, and that words continued to be more attracting than pictures. This suggests that they had little control over what should be looked at first and what should sequentially be examined next. Poor readers also made fewer between element comparisons and required more time to match pictures and words.

Good readers, on the other hand, were demonstratably better able to decenter attention and conduct more effective visual search. They began processing visual information from the upper quadrant more frequently than did poor readers, and they searched both elements for about equal lengths of time. Good readers also compared pictorial and verbal information more often than poor readers. The above data indicates that poor readers are indeed, as suggested by Mackworth, being drawn to "appealing" features of the stimulus complex. It is also interesting to speculate that poor readers may have already developed some failure expectancies in relation to verbal material. In other words, it may be that poor readers have preconceived expectations that they will have difficulty analyzing words and are therefore drawn to them.

Together the above empirical findings and theoretical positions lead to four main conclusions. First, decentrative perceptual activity seems to be related to effective cognitive processing. Secondly, there seems to be a relationship between decentrative perceptual activity, conservation judgement and eye movement behavior. Thirdly, poor readers seem to have more difficulty on conservation tasks, demonstrate more centrative eye movement

patterns, and have more difficulty on pictorial-verbal matching tasks. Finally, it appears that there may be illusionary characteristics associated with words which are perceived as being difficulty by poor readers, and that these illusions may inhibit perceptual-conceptual processing in this reading related task. In line with the above, it seems reasonable that centrated words in the eye movement task, like transformed elements in conservation tasks, may seem larger and more overwhelming to poor readers. Therefore, centration of attention on these words may be creating further illusionary interference in processing task related information.

In summary, the present study combined theoretical aspects of conservation and eye movement research, extended these to a reading related task, and found significant differences between good and poor readers.

## Limitations and Suggestions For Future Research

Limitations along with suggestions for further research will be discussed first in terms of general factors, and then in terms of those factors which have specific relevance to the conservation and eye movement tasks. Although the results of the present study are supportative of previous investigations, as well as related theoretical positions, several qualifications of the findings should be considered.

For example, it may be meaningful for future studies to match good and poor readers on measures of general intelletual ability, such as the Wechsler Intelligence Scale for Children - Revised Form,

in an attempt to reduce the amount of variability of individual scores attributable to possible intellectual differences. Visual anomalies could also interfer with performance, especially on the eye movement task, but this is unlikely in the present study since the trial tasks provided an opportunity for the examiner to check out this possibility. Specifically, when a subject made errors on trial items, they were asked to identify random letters on the screen, as well as items within pictures, to rule out the possibility of visual difficulties. One subject (a good reader) wore glasses at the time of testing and could not identify items on the screen sufficiently well enough to be included in the study. The possibility of interference from emotional factors also exists, however, both good and poor readers appeared to have adjusted well to the testing situation. This was probably due to the fact that special care was taken to familiarize subjects with the oculometric apparatus prior to testing.

More specifically, conservation task considerations revealed that the conservation findings are generally supportive of previous research in that differences between the groups were most noticeable on weight and length tasks. However, differences between good and poor readers on conservation explanations of discontinuous quantity should be further investigated. Perhaps a battery of three conservation tests including length, weight and discontinuous quantity could be developed for use in future reading studies, as these tasks appear to best differentiate between the groups. In addition, repeated measures of performance on these tasks would provide more

reliable indications of conservation status than the one trial attempts scored by the Goldschmid and Bentler test. It also seems important to monitor the eye movement patterns of good and poor readers on conservation tasks. A comparison of ocular performance of good and poor readers, involved in solving conservation problems could empirically evaluate whether poor readers do, in fact, demonstrate centrative attentional patterns on such tasks.

Eye movement task considerations indicated that the generalizability of the effects observed on the eye movement task is somewhat limited as there were only 10 subjects in each group. The sample was unfortunately reduced due to apparatus problems as well as data loss. This resulted in problems of internal validity, and therefore generalizability. However, since the principals of randomization do not appear to have been violated, the data still is meritous. It is compelling to note also that the effects were observed even on the limited number of subjects used in this study. A more extensive study in this area, however, should incorporate the use of a larger sample. Further investigations, using a larger number of good and poor readers, would fascilitate an in-depth analysis of particular centrative effects. In line with this, an examination of within element processing seems important in that a comparison of runs (consecutive fixations within elements) could further clarify processing differences in good and poor readers.

A future study could also include the use of a post test which required subjects to read the words in the tasks aloud. Then data could be collected which would help explain whether poor readers

spent time on words that they did not know, or whether they actually knew the words and still spent extra time looking at them. Perhaps a more extensive examination of subjects in terms of a total time base, rather than the first three seconds of exposure would also serve to clarify attentional-behavioral differences.

An important next step in this area of investigation would be to monitor eye movement patterns of good and poor readers on a task more directly related to actual reading situations. An eye movement study which utilized sentences varying in complexity of words and in grammatical structure for example would be of considerable value.

## Educational Implications

The results and discussions of the present study implicate perceptual-attentional variables as being central to the reading group differences. Moreover, it was concluded that centration on particular graphic aspects in visual exploration seems to result in a dysfunction in coding of information available to the reader. Educationally, the above implies that programs involving the training of selective perceptual attention may be of particular value for teaching poor readers how to efficiently scan for relevant information.

In line with the above, Elkind (1969) has outlined specific procedures for training perceptual activity for retarded readers which follow Piagetian developmental stages. The present study lends support to the emphasis which he places on the importance of training perceptual attentional behavior in that poor readers were found to

centrate attention rather than examine informationally important aspects of visual arrays. Examples of his suggested exercises in the areas of perceptual exploration, reorganization, classification, and schematization follow.

Specifically, Elkind suggests that exercises which train left-right exploration and serial relationships could require the child to complete series of letters or patterns such as, ABC, BCD, CDE, ___. For exercises in visual reorganization, words could be displayed that are meaningful when written either forwards or backwards; e.g., WAS=SAW, or words could be displayed which are to be unscrambled; e.g., ENT=___. He further suggests that classification can be indirectly encouraged through utilization of classes of words as an "orienting set"; such as, numbers, colors or fruits. Perceptual schematization abilities are said to be trained through exercises designed to develop an understanding of logical symbols and relations; for example,

The above type of techniques can apparently be used either pictorally or verbally. Elkind cautions, however, that these exercises are designed to aid a reading program and thereby do not eliminate the need for training in phonics, vocabulary and comprehension.

## Concluding Statement

This study met its objective in that perceptual-conceptual differences were identified between good and poor reading groups. These differences were noticeable in terms of measures of decentration of attention, initial search strategies and effectiveness of

visual search. Several considerations for future research and educational implications were presented.

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# APPENDIX A

## DESCRIPTIONS OF CONSERVATION SUBTASKS

### Form A

Two-dimensional space. This task first required the child to compare the equality or inequality of two lines of six blocks. Two blocks were added to one line and a comparison was required along with an explanation of what transpired. Next two squares of sixteen blocks each were presented for comparison, then one was transformed into pyramed shape and a comparative response as well as a rational was requested.

Number. Here the child was asked to compare the number of chips in two parallel rows of six chips each before and after the chips in one row were moved closer together and the chips in the other row were moved farther apart.

Substance. Two equal balls of Pla-Doh were presented to the child for varification, where upon one was rolled into a sausage shape. The child was then required to compare the relative amounts of substance in the ball and in the sausage and explain his answer.

Continuous quantity. First the child was asked to compare the quantity of water in two identical containers, filled to the same mark. Water was added to one, then they were compared and the one with more water was poured into a dish for a further comparison. Next equal amounts of water in identical glasses were presented, and the process described previously was repeated. The subject was

asked to comment on the transformation.

Discontinuous quantity. Using a procedure similar to that used in the continuous quantity task, except corn was substituted for water, the child was asked to compare the equality or inquality of corn in 5 small glasses with a larger untransformed glass and explain his response.

Weight. In a procedure similar to that of the substance task, the child was asked to compare the weight of one ball of Pla-Doh with that of a flattened ball, and explain his response.

Form B

Area. Using identical green boards as "pastures", the child was asked to compare the amount of "grass" on each field, as equal numbers (12) of "barns" were placed on each. On one board the objects were placed side by side, while on the other they were spread apart. The child was required to explain his response.

Length. The alignment of two identical length sticks was altered, first one was moved ahead of the other, later one was placed between two Muiller-Lyer illusion arrow heads. In all cases explanations were required.

# APPENDIX B

## CRITERION FOR COMPLEXITY OF STIMULUS MATERIAL

Pictures for the stimulus material were chosen from Gates-MacGinities Reading Tests Primary Levels 1, 2, and 3 of Form A (1964). It is important to note that Form B was used to differentiate good and poor readers in the sampling procedure, therefore, the stimulus items presented pictures which were unfamiliar to the subjects. In addition, slight modifications were made to the pictures in order to facilitate identification of different degrees of complexity. The words were, for the most part, taken from the same tests, or when necessary, from the Thorndike-Lorge Teacher's Word Book of 30,000 Words (1968), here words familiar to grades 1, 2 and 3 students were chosen.

The stimulus material were presented on 8 x 5 cards to nine different judges to sort into categories outlined according to levels of complexity of pictures and words. The instructions given to the judges were as follows:

> The cards in front of you display words and pictures which have been selected for use in examining attentional-behavioral differences in good and poor readers on pictorial-verbal matching tasks. Would you please sort the words first, and then the pictures into three categories (piles) according to the following instructions:

Pictures

Easy - single picture

- one concrete object
- outlines and contours easily identifiable
- minimum of detail

Medium - two pictures

- objects of persons - depicting an event, happening or action
- outlines and contours more complex
- identification of the action or concept involves examination of picture details.

Difficult - four pictures

- a series of events or actions or objects (not sequential)
- outlines and contours complex within pictures
- discriminating between pictures in complex due to the similarities between pictures as well as the increase in number of pictorial stimuli.

Words

Easy - 3 letters in length

- all of the 4 words begin with <u>different</u> letters
- letter discriminations (differences) quite distinct between all of the words

Medium - 4 to 5 letters in length

- 2 out of 4 words begin with the <u>same</u> letter
- in addition 2 out of 4 words (regardless of the beginning letters have middle letters or ending alike
- letter discrimination less distinct due to similarities between words

Difficult - at least 6 letters in length

- all 4 words being with the <u>same</u> letter

- all 4 words have middle letters or ending letters alike

- discriminating between words is complex due to the multiple letter similarities.

The interjudge agreement on classification of the stimulus items was 99%. It was therefore concluded that the stimulus material presented clearly distinguished levels of difficulty.

Within each category there were three items, thus a total of 27 items were presented to each subject. To control for possible order effects, a random programmed sequence was used for presentation of the items. As stated previously, however, only the data on the items categorized as consisting of difficult pictures and words was analyzed for eye movement variables, due to the overwhelming amount of data collected on each subject and the lack of computer programs to assist in data interpretation. Thus, only information gathered from eye movement patterns on the three stimulus items containing 4 difficult pictures and 4 difficult words were subjected to empirical evaluation.

# APPENDIX C

## Pilot Study

<u>Number of Incorrect Responses</u>

Good Readers

| Words \ Pictures | Easy | Medium | Difficult | |
|---|---|---|---|---|
| Easy | | | 2 | 2 |
| Medium | | 1 | 8 | 9 |
| Difficult | | 3 | 4 | 7 |
| | 0 | 4 | 14 | 18 |

N = 7

Poor Readers

| Words \ Pictures | Easy | Medium | Difficult | |
|---|---|---|---|---|
| Easy | 1 | 2 | 3 | 6 |
| Medium | 5 | | 6 | 11 |
| Difficult | 2 | 8 | 9 | 19 |
| | 8 | 10 | 18 | 35 |

N = 5

# APPENDIX D

## Detailed Scoring Procedure for Eye Movement Task Analysis

To compensate for possible errors of measurement of the location of fixations due to individual variations in curvature of the eye, calibration data was collected on each subject. This data was collected prior to the presentation of actual stimulus material. The first stimulus situation then consisted of nine _x's_ which were displayed individually and in a random order. Eight of these calibration points (_x's_) were positioned at points in the visual array which corresponded to the locations of actual stimulus items (pictures and words). Therefore 4 _x's_ were evenly spaced across the upper portion of the visual array and 4 _x's_ were evenly spaced across the lower portion of the visual array. In addition an _x_ located in the center of the array was shown. Each _x_ was flashed on the screen for 3 seconds.

The purpose of this stimulus situation was to obtain data on each subject that would fascilitate calibration of the system to that subject. This data however, was not utilized in the analysis of the present eye movement variables due to technical problems relating to difficulties encountered in the identification of clusters of fixations on specific calibration points. Instead a more general method of identifying locations of fixations was employed. That is, fixations clearly in the upper quadrants of the stimulus array were considered to be fixations on pictorial

elements, whereas fixations clearly in the lower quadrants were considered to be fixations on verbal elements.

Changes in fixation between element items i.e., from picture to picture or from word to word, were not analyzed as confidence in such measures, without calibration information, was considered questionable. However shifts in fixation between elements i.e., between pictures and words, were easily identified due to the marked separation of pictorial and verbal elements.

APPENDIX E

RAW SCORE DATA ON EYE MOVEMENT VARIABLES

| Total Number of Fixations | Number of Fixations on Pictures | Number of Fixations on Words | Summated Mean Length on Fixation | Mean Length of Fixation on Pictures | Mean Length of Fixation on Words | Number of Couplings | Response Latency |
|---|---|---|---|---|---|---|---|
| Good Readers | | | | | | | |
| 53 | 36 | 17 | 5.09 | 5.14 | 4.53 | 15 | 271.00 |
| 25 | 9 | 12 | 10.80 | 11.66 | 10.91 | 8 | 199.00 |
| 54 | 19 | 29 | 5.00 | 6.21 | 4.54 | 13 | 416.67 |
| 31 | 16 | 14 | 8.70 | 10.25 | 5.13 | 11 | 269.33 |
| 40 | 14 | 26 | 6.75 | 4.86 | 7.76 | 7 | 403.67 |
| 41 | 24 | 17 | 6.56 | 5.91 | 7.94 | 7 | 357.00 |
| 27 | 15 | 11 | 10.00 | 9.71 | 11.63 | 7 | 235.33 |
| 45 | 23 | 14 | 6.00 | 6.63 | 8.21 | 9 | 486.33 |
| 32 | 16 | 12 | 8.44 | 7.91 | 10.42 | 12 | 257.67 |
| 31 | 12 | 14 | 8.71 | 10.27 | 9.78 | 5 | 235.33 |
| Poor Readers | | | | | | | |
| 25 | 12 | 13 | 11.25 | 10.91 | 12.91 | 10 | 299.00 |
| 58 | 16 | 34 | 4.66 | 3.31 | 5.83 | 7 | 211.67 |
| 35 | 9 | 21 | 7.71 | 6.67 | 9.95 | 5 | 1469.00 |
| 25 | 12 | 11 | 10.80 | 9.83 | 11.82 | 6 | 899.67 |
| 29 | 12 | 17 | 9.31 | 10.77 | 9.20 | 8 | 547.00 |
| 50 | 20 | 26 | 9.01 | 4.50 | 14.00 | 17 | 258.00 |
| 27 | 14 | 12 | 5.40 | 4.77 | 7.73 | 8 | 294.67 |
| 25 | 7 | 18 | 10.00 | 9.71 | 10.08 | 5 | 306.33 |
| 18 | 11 | 6 | 10.80 | 8.00 | 11.93 | 5 | 1195.67 |
| 44 | 14 | 24 | 15.00 | 8.42 | 27.50 | 9 | 597.67 |



92.